

## Studies on North-West Himalayan Russulaceae

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**ABSTRACT:** North Western Himalayan forests are rich in macrofungal diversity, especially in ectomycorrhizal (ECM) fungi. In 2014 and 2015, a number of explorations were undertaken during rainy season to explore the ECM diversity. The morpho-taxonomy of thirteen samples of Russulaceae were briefly discussed. Four samples of *Lactarius* and nine samples of *Russula* were described morphologically and illustrated taxonomically. Detailed study on the spore morphology of the specimens was carried out using staining techniques and Scanning Electron Microscopy (SEM). Out of these *Lactarius paradoxus*, *L. subpurpureus*, *Russula fellea*, *R. flavida* and *R. subfoetens* have been reported for the first time from Himachal Pradesh.

**Keywords:** Basidiomycetes, macrofungi, *Russula*, *Lactarius*, taxonomy.

### INTRODUCTION

The members of family Russulaceae belongs to cosmopolitan group of ectomycorrhizal mushroom that forms a relationship with trees. It comprises around 1900 accepted species (Lebel *et al.*, 2013). Major genera of this group are *Russula*, *Multifurca*, *Lactarius* and *Lactifluus* are easily distinguished from other gilled mushrooms by the consistency of their flesh, which is granular, brittle, breaks easily and absence of volva. *Lactarius* consists of 450 spp. worldwide (Kirk *et al.*, 2008) and 83 from India (Upadhyay *et al.*, 2017). *Russula* consists of 750 spp. worldwide (Kirk *et al.*, 2008) and 128 spp. from India (Upadhyay *et al.*, 2017). In the present study four species of *Lactarius*: *L. camphoratus*, *L. paradoxus*, *L. salmoneus*, *L. subpurpureus* and nine species of *Russula*: *R. atropurpurea*, *R. brevipes* var. *acrior*, *R. delicata*, *R. flavida*, *R. fellea*, *R. foetens*, *R. fragilis*, *R. grisea*, *R. subfoetens* were reported from forests of Himachal Pradesh. Two *Lactarius* (*L. paradoxus* and *L. subpurpureus*) and three *Russula* (*R. fellea*, *R. flavida* and *R. subfoetens*) are first time documented from Himachal Pradesh.

### MATERIALS AND METHODS

Specimens were collected during rainy season. Specimens were photographed and all the morphological traits such as colour, shape, size and change in colour on bruising of carpophores on touch

and injury, latex colour and latex colour change were described in the field from the fresh specimen.

All colour notations were according to Kornerup and Wanscher, (1978). After recording all the morphological characters, specimens were dried in hot air oven and preserved in polypropylene bags with naphthalene ball and some crystals of 2,4-dichlorobenzene. Microscopic studies were done from dried sample revived in 3% KOH. Hymenium, basidia, cystidia, pileipellis and stipeipellis were observed in 1% Congo red and 1% cotton blue under oil immersion (Motic BA 310). Spores were studied from the spore deposits in Melzer's reagent. Camera lucida drawings were made with the aid of a drawing tube. Spore ornamentations were observed by SEM using EMCRAFT microscope. The examined collections were deposited in the Herbarium of ICAR, Directorate of Mushroom Research, Chambaghat, Solan, (H.P.).

### RESULTS

*Lactarius camphoratus* (Bull.) Fr., Epicrisis Systematis Mycologici: 346, 1838 [Figs. 1 (A–H) and 2 (A–F)]

Pileus diameter up to 4.0 cm wide, umbonate, greyish orange (6B-5) to (6B-4), surface non hygrophanous, margin irregular, striate, inflexed, dry, smooth, scales absent, cuticle not peeling, pileus consistency fleshy, context colour cream, up to 0.1cm thick, no colour change on touch or handling and confluent pileus. Lamellae shortly decurrent, close, separable, flesh coloured (6B-3), fleshy, gill size 2.0 × 0.2 cm unequal

present in 5 sets of lamellulae, secrete milky latex when injured. Stipe central, light brown (6D-5) to brown (6E-5), cylindric  $8.5 \times 0.3$  cm, terete, dry, glabrous, blunt at the base, hollow, fleshy, stipe trama colour cream, ring, veil and volva absent.

Basidiospores  $(7.2)8.0\text{--}(8.8) \times (5.8)6.5\text{--}(7.6) \mu\text{m}$  ( $Q=1.1\text{--}1.3$ ), hyaline, ornamented, subglobose to elliptical, apiculate ( $0.9\text{--}1.5 \mu\text{m}$ ), germ pore absent, oil globule present, cyanophilic and amyloid. Basidia  $(26.4)30.8\text{--}(35.6) \times (7.4)9.4\text{--}(12.9) \mu\text{m}$  ( $Q=3.3$ ), clavate, 2, 4-spored, basidia mostly tetra-sterigmatic, long curved sterigmata up to  $5.5 \times 1.7 \mu\text{m}$ , thin walled, oil globule present, basal septa without clamps. Pleurocystidia present,  $(33.0)38.5\text{--}(49.8) \times (7.5)10.0\text{--}(12.0) \mu\text{m}$ , cheilocystidia  $(24.3)28.8\text{--}(35.0) \times (5.4)6.8\text{--}(9.0) \mu\text{m}$ . Pileipellis  $(10.2)14.8\text{--}(22.7) \times (8.8)12.1\text{--}(17.2) \mu\text{m}$  thick, hyphae irregularly arranged, thin walled, with some cylindrical hyphae. Hymenophoral trama  $(3.9)5.3\text{--}(8.8) \mu\text{m}$  thick, regular. Subhymenium  $6\text{--}13 \mu\text{m}$ . Hymenium  $17\text{--}23 \mu\text{m}$ . Stipe cuticle  $(6.4)7.9\text{--}$

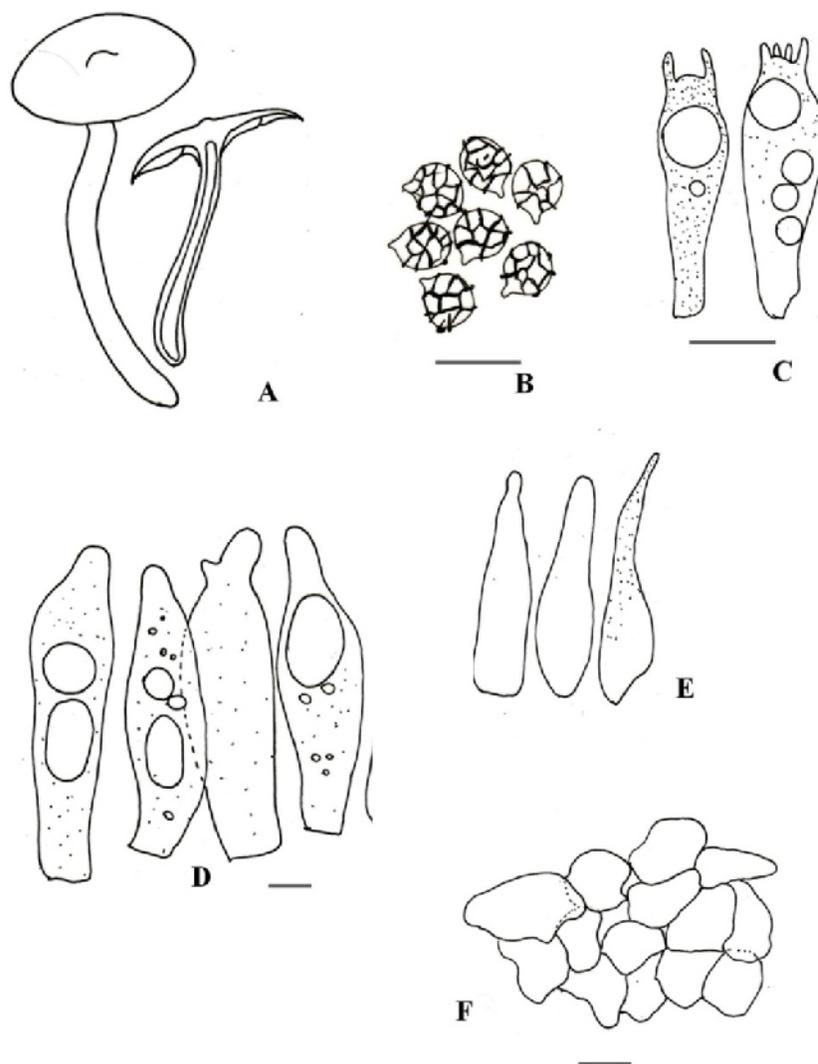
$(11.3) \times (3.5)4.9\text{--}(9.7) \mu\text{m}$  wide, septate, branched, septa without clamps.

**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l.; GPS  $31^{\circ}6'0''$   $N77^{\circ}15'0''E$ , mixed forest, under Pine tree. Shilpa Sood, DMR Acc. No. 23/15, July 26, 2015.

**Discussion.** *L. camphoratus* has been misidentified as *L. rubidus* due to red brown pileus, close to crowded pale pinkish cinnamon lamellae. However, *L. rubidus* is a European and Eastern North American species featuring watery latex and absence of pleurocystidia. *L. camphoratus* can be identified due to variable cystidia from subclavate, subcylindric to fusiform, irregular and nearly lobed. It is also confused with *L. fragilis* which has watery latex yellowish gills, and (more definitively) spores that are reticulate. This genus is already reported from Himachal Pradesh: Bhatt and Lakhanpal, (1990); Uttarakhand: Bhatt *et al.*, (2000), Das and Sharma, (2002).



**Fig. 1 (A–H) *Lactarius camphoratus*:** A) Basidiocarps in natural habitat; B) Basidiocarp with slight umbo; C) Gills with milky latex; D) Lobed cystidia; E) Pileipellis; F) Basidiospores in light microscope; G and H) SEM of basidiospores. Scale bars: D–F=10  $\mu\text{m}$ ; G=1  $\mu\text{m}$ ; H=2  $\mu\text{m}$ .



**Fig. 2 (A–F) *Lactarius camphoratus*: A) Basidiocarp; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis. Scale bars: B–F=10  $\mu$ m.**

*Lactarius paradoxus* Beardslee & Burl., Mycologia 32: 586, 1940 [Figs. 3 (A–F) and 4 (A–H)]

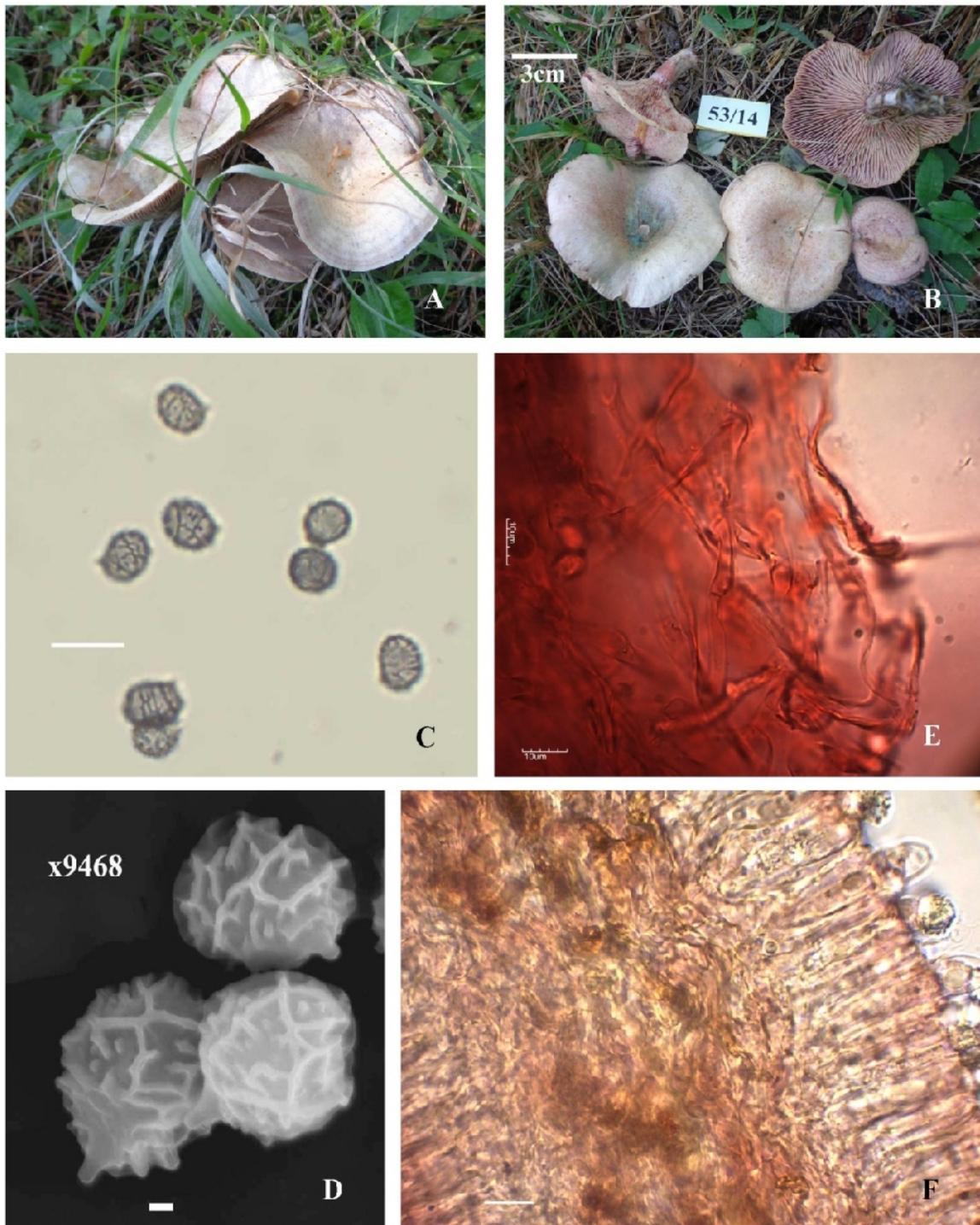
Pileus up to 8.7 cm diam. depressed, purplish pink (14A-3) to reddish lilac (14B-3), regular, wavy, non-striate, with concentric zones, inflexed, moist, non hygrophanous, smooth, scales absent, fleshy, colour change on touch pale blue (21A-3). Lamellae purplish white (14A-2) to purplish pink (14A-3), adnate, unequal, close, separable, 7 sets of lamellulae, fleshy, interveined, separable, latex blood red in colour. Stipe 2.9  $\times$  1.2 cm, central, purplish white (14A-2), cylindric, blunt, hollow, terete, fleshy, ring, veil and volva absent. Basidiospores (8.8)9.1–(9.3)  $\times$  (5.1)6.0–(7.2)  $\mu$ m (Q=1.5), hyaline, elliptical, reticulate, SEM studies showed ornamentation up to 0.5  $\mu$ m high, of rather thick ridges, forming an almost complete reticulum, isolated warts scarce, plage distinct less isolated warts and slightly amyloid, apiculate (0.8–1.4  $\mu$ m), germ pore

absent, oil globule present (1–2 in no.), cyanophilic and amyloid. Basidia (38.2)43.4–(50.5)  $\times$  (6.7)8.8–(10.7)  $\mu$ m, (Q=4.9), clavate, 4-spored, sterigmata up to 6.0  $\times$  1.9  $\mu$ m, thin walled, oil globule present, basal septa without clamps. Pleurocystidia present, fusiform to moniliform (37.6).59.2–(70.6)  $\times$  (4.6)7.8–(8.6)  $\mu$ m, cheilocystidia present (19.6)24.7–(37.6)  $\times$  (3.6)5.9–(8.2)  $\mu$ m, same as like pleurocystidia, oil globule present, clamp connections absent. Pileipellis ixocutis. Hymenophoral trama (3.3)8.8–(14.4)  $\mu$ m thick with laticiferous hyphae. Subhymenium 15–22  $\mu$ m. Hymenium 35–45  $\mu$ m. Stipe cuticle regular strongly interwoven hyphae (1.8)2.9–(4.2)  $\mu$ m.

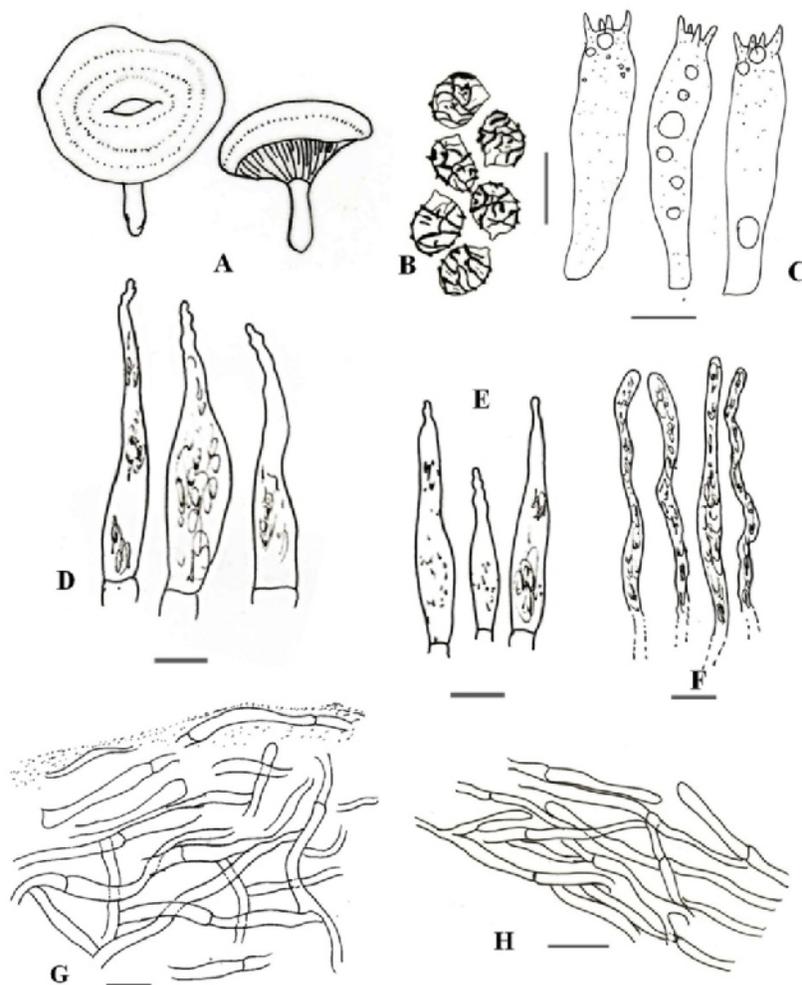
**Collection examined:** India- Himachal Pradesh-Shimla- Narkanda- Oddi: alt. 2621 m a.s.l.; GPS 32°9'52"N 76°16'39"E, coniferous, gregarious, on soil among grasses. Shilpa Sood, DMR Acc. No. 53/14, September 21, 2014.

**Discussion.** *L. paradoxus* is a medium sized species, characterized by the bluish and often greenish tinges in the pileus and the vinaceous red to brown latex. Remarkable is the short root-like projection of the stipe. Hesler and Smith, (1979) reported several collections

with differently ornamented spores. From India, Atri and Saini, (1986) first reported this species from Uttarakhand. In the present investigation the specimen was found scatter to gregarious in coniferous forest and reported first time from Himachal Pradesh.



**Fig. 3 (A–F) *Lactarius paradoxus*:** A and B) Basidiocarps in natural habitat; B) Basidiospores showing zonation in pileus surface and gill attachment; C) Basidiospores in light microscope; D) Basidiospores in SEM; E) Pileipellis; F) Section showing abundant laticifer hyphae in gill trama. Scale bars: C, E and F=10 µm; D=1 µm.



**Fig. 4 (A–H) *Lactarius paradoxus*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pseudocystidia; G) Pileipellis; H) Stipitipellis. Scale bars: B–H=10  $\mu$ m.**

*Lactarius salmoneus* Peck, Bulletin of the Torrey Botanical Club 25: 369, 1898

[Figs. 5 (A–G) and 6 (A–H)]

Pileus diameter up to 6.5 cm wide, convex, becoming nearly applanate or slightly depressed in the centre, greyish orange (6B-3) to orange grey (6B-2), surface hygrophanous, regular, inflexed, sulcate, moist, glabrous, velvety, cuticle not peeling, pileus consistency fleshy, flesh colour light orange, upto 0.3 cm thick, colour change on touch or handling to green (26B-7). Lamellae adnate, unequal, 5 sets of lamellulae,  $3.2 \times 0.3$  cm in size, fleshy, orange salmon colour, sub distant, separable, intervened, 10 lamellae per cm near the margin, latex salmon in colour. Stipe central, cylindric,  $4.0 \times 1.0$ – $1.5$  cm, light orange (6A-4), terete, blunt, smooth, fleshy, glabrous, hollow, ring veil and volva absent.

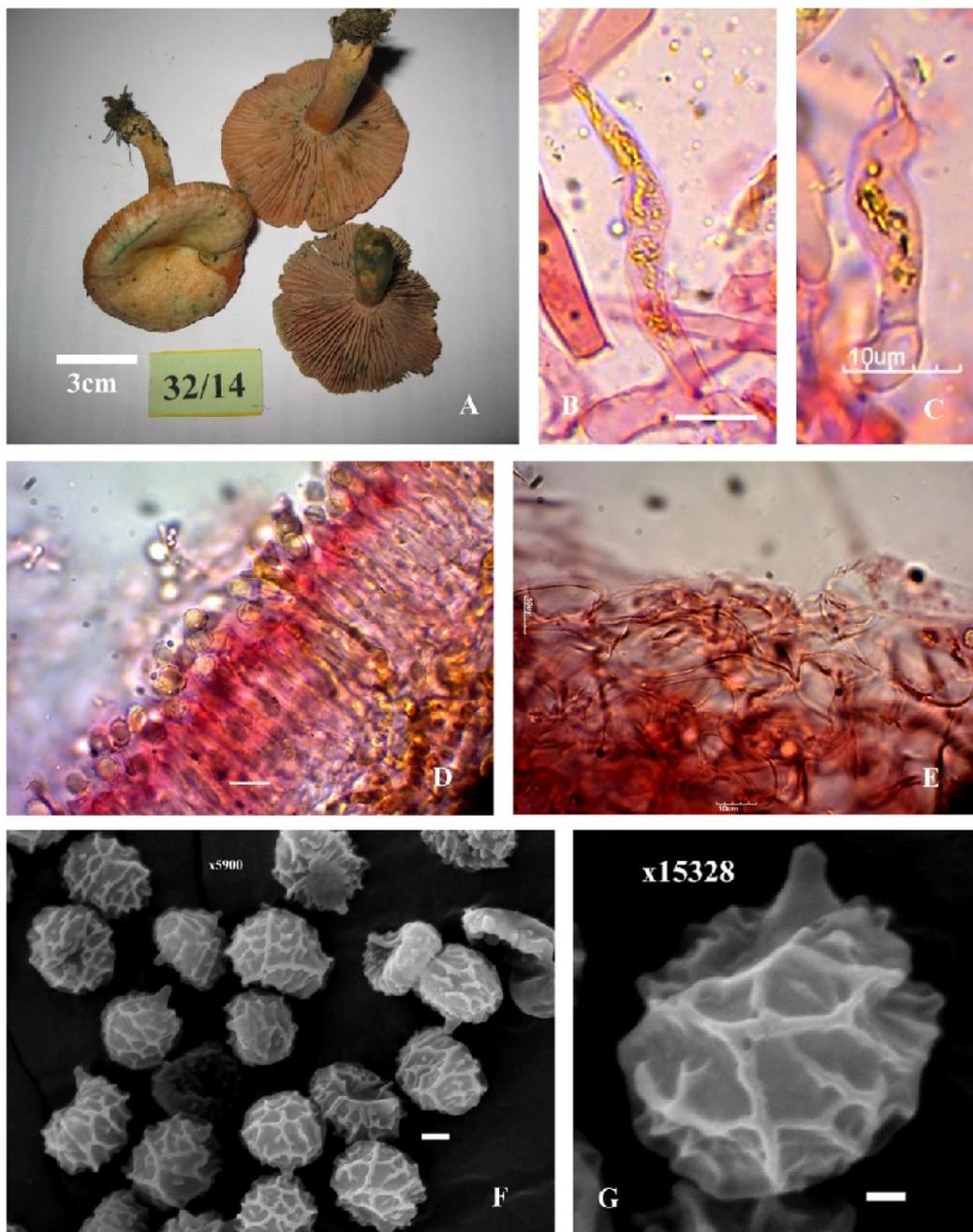
Basidiospores  $(7.4)7.9$ – $(8.6) \times (4.9)5.6$ – $(6.5) \mu$ m, ellipsoid to broadly ellipsoid (Q=1.3–1.5), hyaline, ornamented, thin walled, apiculate (0.5–1.1  $\mu$ m), germ

pore absent, oil globule present, cyanophilic and amyloid, shows reticulation in Melzer's reagent, SEM studies revealed ornamentation upto 0.4  $\mu$ m high, of medium thick ridges and some finer lines, forming an incomplete reticulum, isolated warts rather scarce. Basidia  $(41.5)51.9$ – $(61.6) \times (6.5)7.1$ – $(8.3) \mu$ m (Q=7.3), clavate, 2, 4-spored, sterigmata up to  $(3.0)3.4$ – $(3.9) \times (0.9)1.2$ – $(1.3) \mu$ m, thin walled, oil globule present, basal septa without clamps. Pleurocystidia present, subfusiform to moniliform,  $(33.8)40.5$ – $(52.7) \times (4.8)5.8$ – $(7.1) \mu$ m, pseudocystidia present  $(2.4)4.0$ – $(5.0) \mu$ m, cheilocystidia present  $(17.5)24.7$ – $(30.2) \times (4.2)5.1$ – $(6.8) \mu$ m subfusiform to moniliform. Pileipellis 0.5–1.0  $\mu$ m, thin walled cutis with local trichodermium inclinations. Hymenophoral trama  $(2.9)4.0$ – $(7.7) \mu$ m thick, irregular with abundant laticifer hyphae. Subhymenium 10–15  $\mu$ m. Hymenium 24–40  $\mu$ m. Stipitipellis strongly interwoven hyphae  $(1.1)2.4$ – $(4.0) \mu$ m diam.

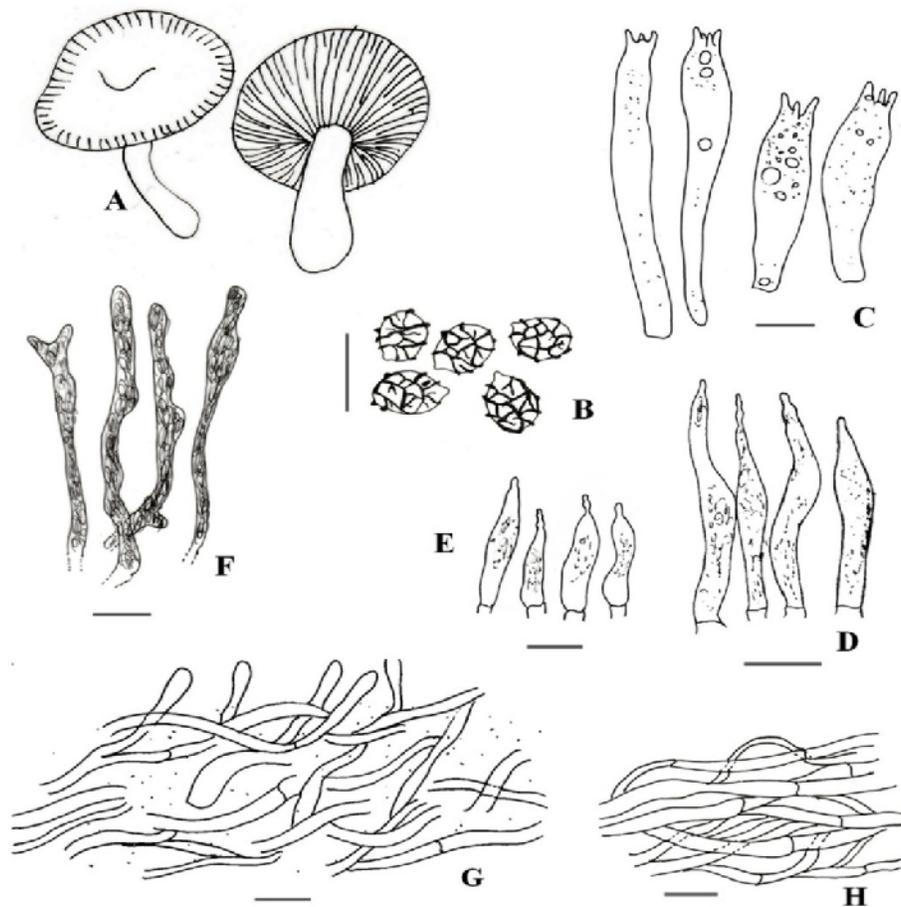
**Collection examined:** India- Himachal Pradesh- Dharamshala- Sarah: alt. 1012 m a.s.l; GPS 32°11'18"N 76°18'9"E, scattered, growing on soil, under Pine tree covered with fallen leaves. Shilpa Sood, DMR Acc. No. 32/14 September 13, 2014.

**Discussion.** The fungus belongs to *L. salmoneus* subgenus *Piperites* due to its enrolled margins and cuticle an ixotrichoderm (Heilmann-clausen *et al.*, 1998). Examined collection is characterised by the presence of dry to sub velvety white cottony felt both on the pileus and stipe, salmon coloured latex, surface

staining greenish, presence of pleurocystidia, spores 7.4–8.6 × 4.9–6.5 μm with incomplete reticulation and isolated warts which are typical characters of *L. salmoneus*. It closely resembles to *L. curtisii* but differ from *L. curtisii* in having salmon coloured latex and presence of pleurocystidia which are absent in *L. curtisii* although having the same spore size. In the present study, it was collected from coniferous forest in association with *Pinus roxburghii*, in wet place in the month of September.



**Fig. 5 (A–G) *Lactarius salmoneus*:** A) Basidiocarps; B) Pleurocystidia; C) Cheilocystidia; D) Section showing pseudocystidia and laticifer hyphae in hymenium; E) Pileipellis; F and G) Basidiospores in SEM. Scale bars: B–E=10 μm; F=2 μm; G=0.8 μm.



**Fig. 6 (A–H) *Lactarius salmoneus*:** A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pseudocystidia; G) Pileipellis; H) Stipitopellis. Scale bars: B–H=10  $\mu$ m.

*Lactarius subpurpureus* Peck, Annual Report on the New York State Museum of Natural History 29: 43, 1878

[Figs. 7 (A–G) and 8 (A–H)]

Pileus diameter up to 15.1 cm wide, shallowly depressed, dull red (10B-3) to (10B-4), gives green colour with age or on bruising greyish green (25C-4) to (25C-6), surface hygrophanous, margin irregular, sulcate margin, showed some zonation, glabrous, scales absent, inflexed, moist, cuticle not peeling, pileus consistency fleshy, context colour light red, up to 0.5 cm thick, confluent pileus separation. Lamellae adnate, reddish orange, distant, fleshy, separable, gill size 7.3  $\times$  1.1 cm, unequal present in 4 sets of lamellulae, secrete deep red coloured latex when injured. Stipe central, pastel red to pale red (10A-3), cylindric 5.0  $\times$  1.8 cm, terete, glabrous, hollow, fleshy, trama light red in colour.

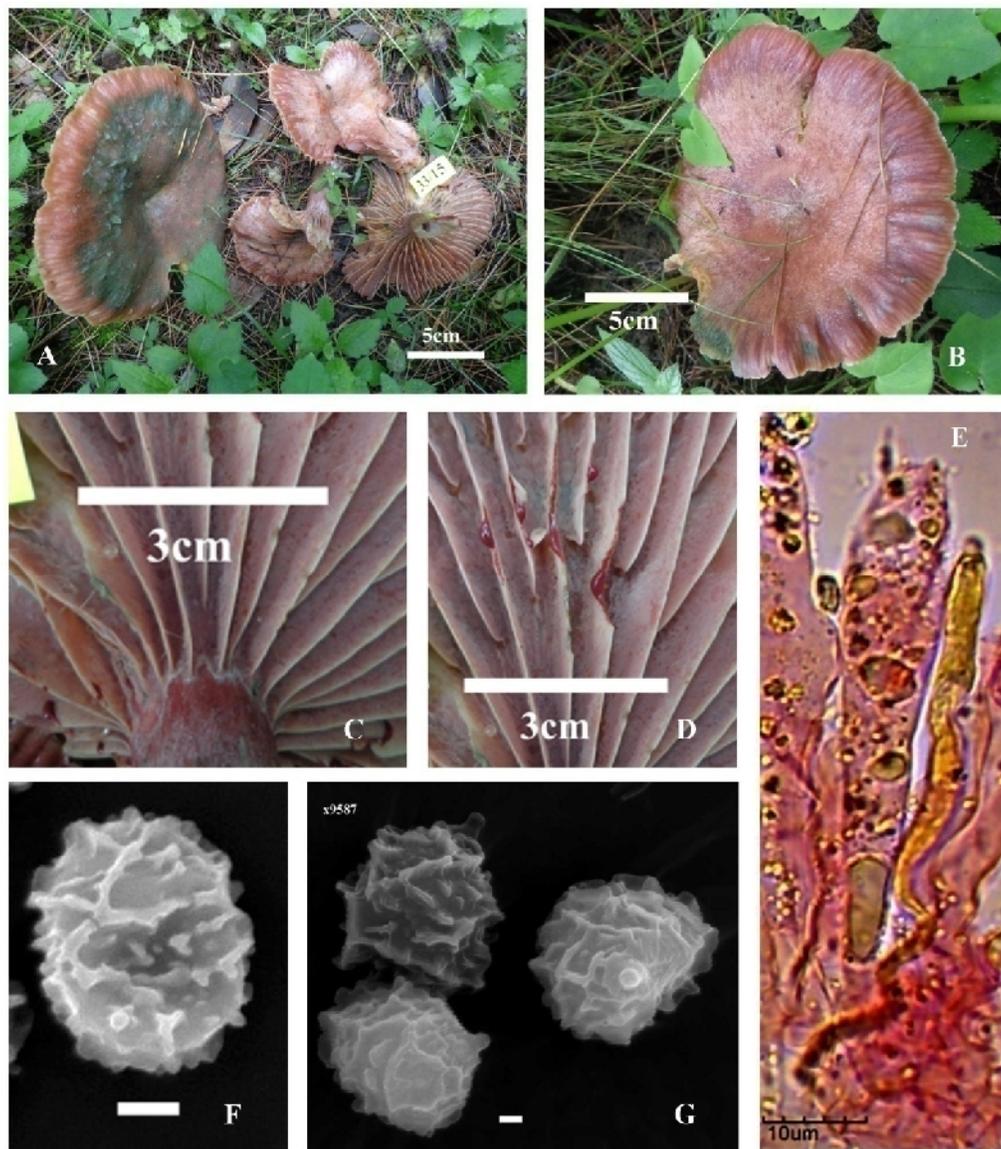
Basidiospores (7.8)8.5–(9.4)  $\times$  (5.2)5.8–(7.0)  $\mu$ m (Q=1.5), broadly ellipsoid to ellipsoid, ornamentation amyloid, up to 0.7  $\mu$ m, composed of thick ridges with some fine connections and isolated warts forming incomplete reticulation in SEM, hyaline, thick walled, apiculate (1.0–1.4  $\mu$ m), germ pore absent, oil globule

present (1 large), cyanophilic and amyloid, spore deposit white. Basidia (39.8)45.6–(55.2)  $\times$  (7.3)8.9–(9.9)  $\mu$ m (Q=5.1), clavate, 1,2,4-spored, sterigmata up to 5.3  $\times$  1.5  $\mu$ m, thin walled, oil globule present in some, basal septa without clamps. Pleurocystidia present, fusiform to moniliform, (46.6)52.4–(63.1)  $\times$  (2.8)4.7–(7.2)  $\mu$ m, pseudocystidia present (43.3)52.9–(71.9)  $\times$  (1.6)3.2–(3.7)  $\mu$ m, cheilocystidia present same as pleurocystidia, (30.4)35.6–(39.1)  $\times$  (3.4)6.3–(8.7)  $\mu$ m. Hymenium 35–50  $\mu$ m. Pileipellis an ixocutis made up of 1.0–2.0  $\mu$ m broad, septate, hyphae and lactifers; context made up of rosettes of sphaerocysts intermingled with laticiferous hyphae. Stipitopellis made up of gelatinized, cutis to exocutis, strongly interwoven, regularly arranged hyphae, (2.9)3.3–(4.1)  $\mu$ m wide, septate, branched, context made up of rosettes of sphaerocyst with laticifer hyphae, clamp connections absent.

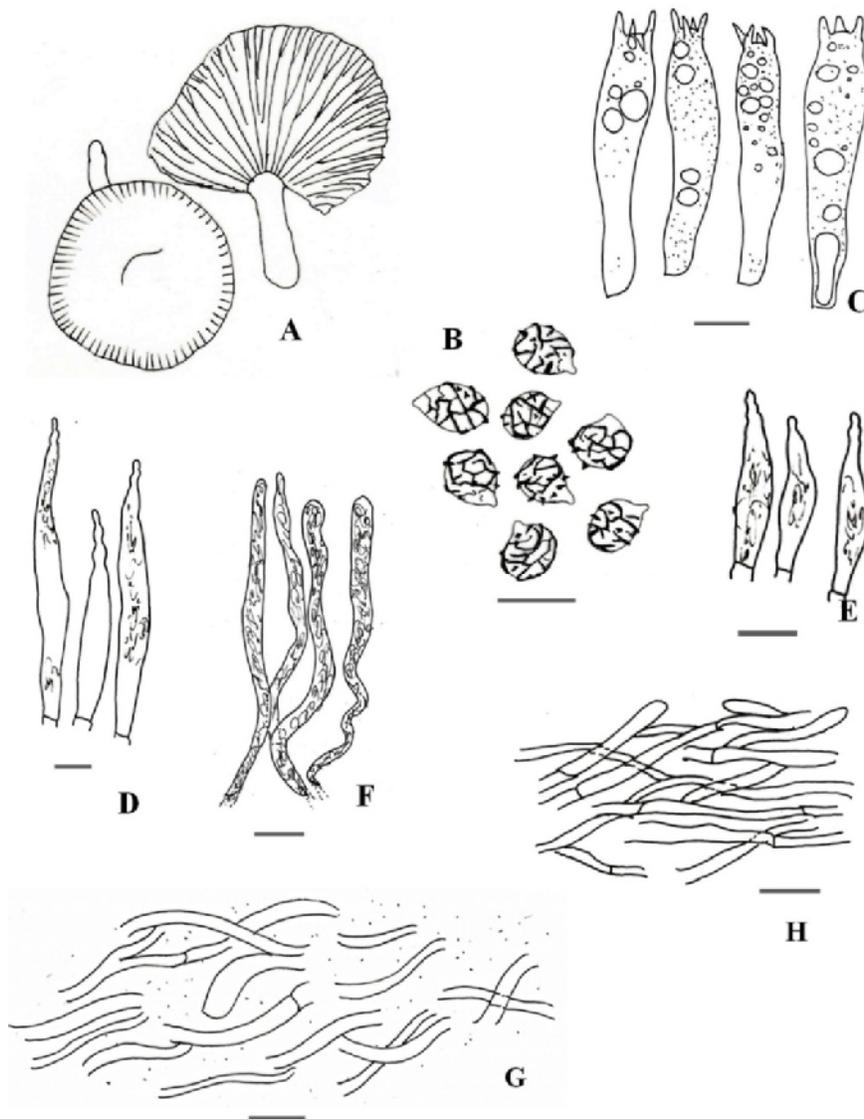
**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l; GPS 31°6'0"N77°15'0"E, coniferous forest, under Pine tree, among grasses. Shilpa Sood, DMR Acc. No. 33/15, July 27, 2015.

**Discussion.** The above examined collections belongs to subgenus *Piperites* due to the presence of feeble concentric zones on the pileus surface, inrolled pileus margin, red coloured latex and presence of ixocutis pileipellis. The dirty pinkish colour of the basidiocarps, white zoned pileus surface with greenish tinge, the vinaceous red latex and the subdistant lamellae make *L. subpurpureus* an easy species to recognise. This species shows close resemblance with *L. rubrilacteus* Hesler & Smith and *L. paradoxus* Beardslee & Burlingham. It differs from the former by its distant to subdistant lamellae and mild to acrid tasting flesh as compared to close to crowded lamellae and mild flesh in *L. rubrilacteus*.

Hymenophoral trama in the present collection is hyphal as compared to cellular trama in *L. rubrilacteus* (Hesler and Smith, 1979). This species differs from *L. paradoxus* by its sub-distant lamellae and large sized basidiospores with incomplete reticulation. Hesler and Smith, (1979) found this fungus growing in association with *Tsuga canadensis* and Pine in coniferous and mixed forest of United States and Canada. From India, for the first time listed this species from Kashmir (Watling and Gregory, 1980; Saini and Atri, 1990) and Uttarakhand (Atri and Saini, 1986. Saini and Atri, 1990; Bhatt *et al.*, 2000; Joshi *et al.*, 2013). This fungus is reported for the first time from Himachal Pradesh.



**Fig. 7 (A–G) *Lactarius subpurpureus*:** A) Basidiocarps in natural habitat; B) Basidiocarp showing zonation; C) Subdeccurrent gill attachment; D) Deep red coloured latex from gills; E) Basidia and pseudocystidia; F and G) Basidiospores in SEM. Scale bars: E=10 µm; F=0.9 µm; G=1 µm.



**Fig. 8 (A–H) *Lactarius subpurpureus*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pseudocystidia; G) Pileipellis; H) Stipitopellis. Scale bars: B–H=10  $\mu$ m.**

*Russula atropurpurea* Peck, Annual Report on the New York State Museum of Natural History 41: 75, 1888 [Figs. 9 (A–G) and 10 (A–F)]

Pileus diameter up to 3.7 cm wide, slightly depressed, deep violet (15D-8) center, margin purplish pink (14A-4) to deep magenta (14D-8), regular, striate, inflexed, moist, non hygrophorous, glabrous, scales absent, fleshy, flesh colour white, no colour change on touch or handling, pileus confluent. Lamellae attached equal, close, light yellow in colour, gill thickness 0.2 cm, fleshy, separable. Stipe 8.2  $\times$  0.8–1.5 cm white, central, cylindric, blunt, fleshy, terete, hollow, glabrous, stipe trama white, ring, veil and volva absent.

Basidiospores (7.3)8.0–(9.2)  $\times$  (5.3)6.4–(8.2)  $\mu$ m (Q=1.3), hyaline, reticulate, thin walled, apiculate (1.1–1.6  $\mu$ m), germ pore absent, cyanophilic and amyloid.

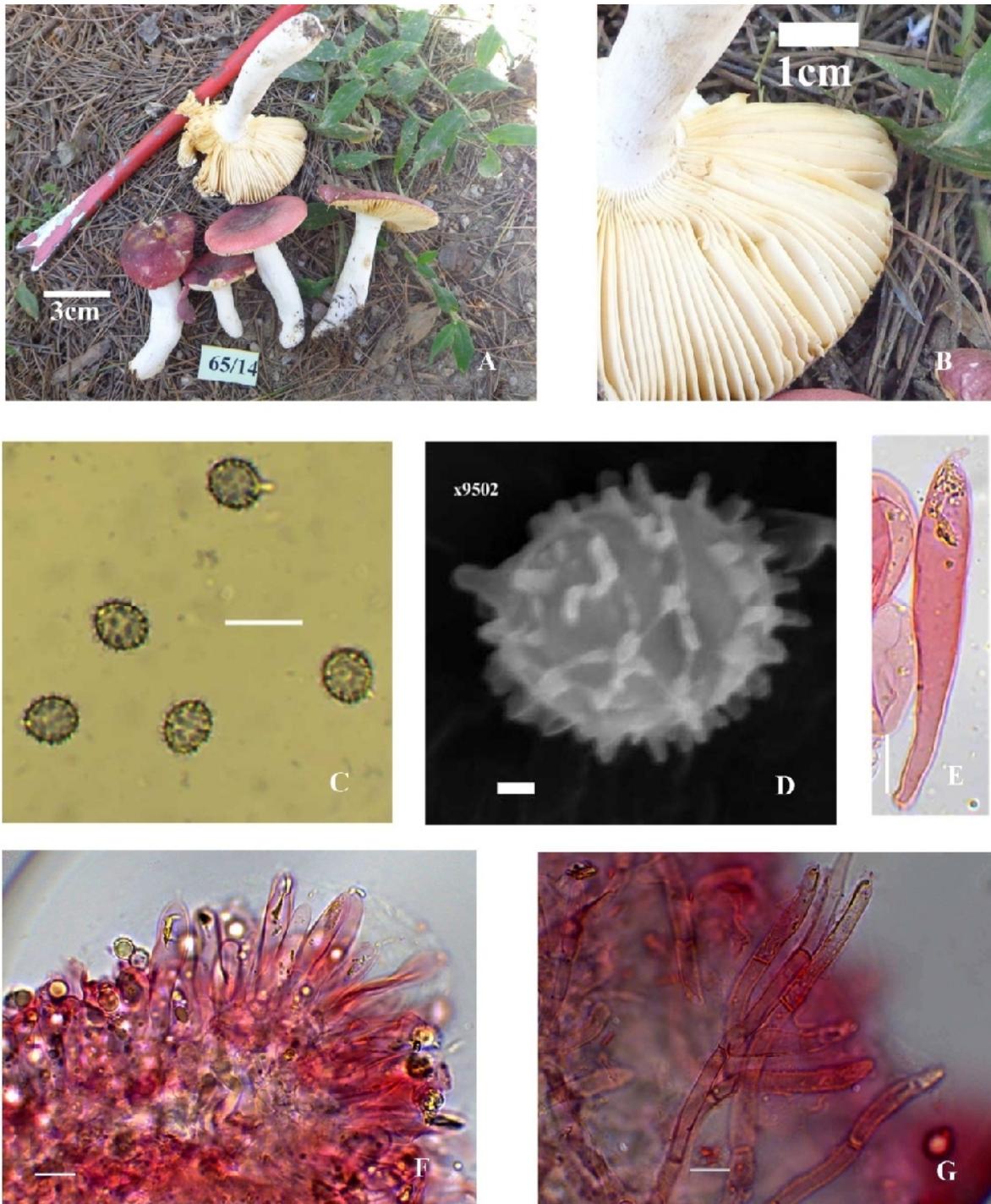
Basidia (33.6)42.1–(49.4)  $\times$  (9.2)11.6–(14.5)  $\mu$ m (Q=3.6), clavate, 2,4-spored, sterigmata up to 4.6  $\times$  1.8  $\mu$ m, thin walled, oil globule in some, clamp connections absent. Pleurocystidia present (41.3)54.4–(65.2)  $\times$  (7.3)9.1–(10.4)  $\mu$ m, cheilocystidia present (31.8)39.8–(50.6)  $\times$  (5.4)7.6–(10.4)  $\mu$ m. Basidiospores (7.3)8.0–(9.2)  $\times$  (5.3)6.4–(8.2)  $\mu$ m (Q=1.3), hyaline, reticulate, thin walled, Pileipellis (3.3)3.9–(4.6)  $\mu$ m, pileus cystidia (33.1)40.2–(44.6)  $\times$  (3.5)5.1–(6.0)  $\mu$ m. Hymenophoral trama (13.9)23.8–(34.8)  $\times$  (13.2)19.0–(25.0)  $\mu$ m composed of sphaerocysts and connective hyphae, laticifer hyphae absent. Subhymenium 25–32  $\mu$ m, single cell (8–10  $\mu$ m). Hymenium 25–40  $\mu$ m. Stipitopellis (2.0)3–(3.9)  $\mu$ m.

**Collection examined:** India- Himachal Pradesh-Shimla- Narkanda- Oddi: alt. 2621 m a.s.l.; GPS 32°9'52"N 76°16'39"E, coniferous, solitary, on soil

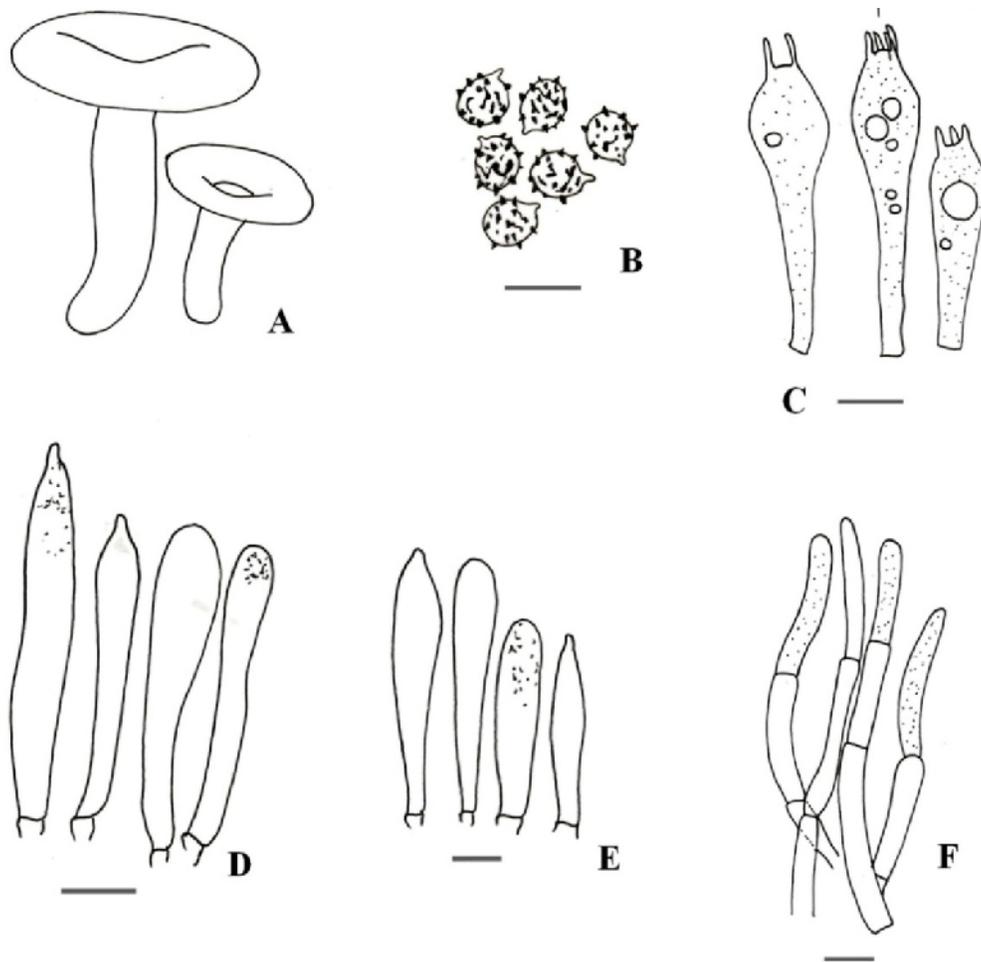
among grasses and dry Pine needles. Shilpa Sood, DMR Acc. No. 65/14, September 21, 2014.

**Discussion.** *R. atropurpurea* belongs to the subgenus *Russula* emend. Sarnari characterized this species by dry to viscid pileus, always bright coloured, red, purple or yellow, smooth, lamellae adnate to subdecurrent, stipe white to concolourous with the pileus, pileus with

septate or aseptate pileocystidia. *R. atropurpurea* is similar to *R. fragilis* which is more fragile. From India it is reported from Uttarakhand: Atri and Saini, (1986); Saini and Atri, (1989) and Kerala: Mohanan, (2011, 2014); Karnataka: Pavithra *et al.*, (2017). In present study specimen is collected from Himachal Pradesh.



**Fig. 9 (A–G) *Russula atropurpurea*:** A) Basidiocarps; B) Gill attachment; C) Basidiospores in light microscope; D) SEM of spore; E) Pleurocystidia; F) Cheilocystidia; G) Pileipellis. Scale bars: C and E–G=10 µm; D=1 µm.



**Fig. 10 (A–F) *Russula atropurpurea*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia F) Pileus cystidia. Scale bars: B–F=10  $\mu$ m.**

***Russula brevipes* var. *acrior*** Shaffer, Mycologia 56 (2): 223 (1964) [Figs. 11 (A–H) and 12 (A–G)]

Pileus diameter up to 13.0 cm wide, infundibuliform, surface white with orange grey (5B-2) to greyish orange (5B-4) patches, surface non hygrophanous, margin regular, non-striate, inflexed, moist, glabrous, scales absent, cuticle not peeling, pileus consistency fleshy, context colour white, thickness 0.5 cm, no colour change on touch or handling and confluent pileus separation. Lamellae adnate, unequal, lamellulae abundant, crowded, cream white, fleshy, separable, interveined, smooth, narrow, gill edge smooth, normal, bluish ring around the stipe, gill size  $6.8 \times 0.3$  cm. Stipe central to excentric, equal  $5.0 \times 3.0$  cm, white, terete in cross section, blunt at the base, smooth, glabrous, no colour change on handling, context stuffed, fleshy, ring, veil and volva absent.

Basidiospores  $(9.3)10.3\text{--}(11.5) \times (6.5)7.6\text{--}(8.9) \mu\text{m}$  ( $Q=1.4$ ), subglobose, hyaline, reticulate ornamentations in the form of isolated warts 2–3 warts connected to form incomplete reticulation, apiculate (1.2–2.0  $\mu\text{m}$ ),

Sood et al.,

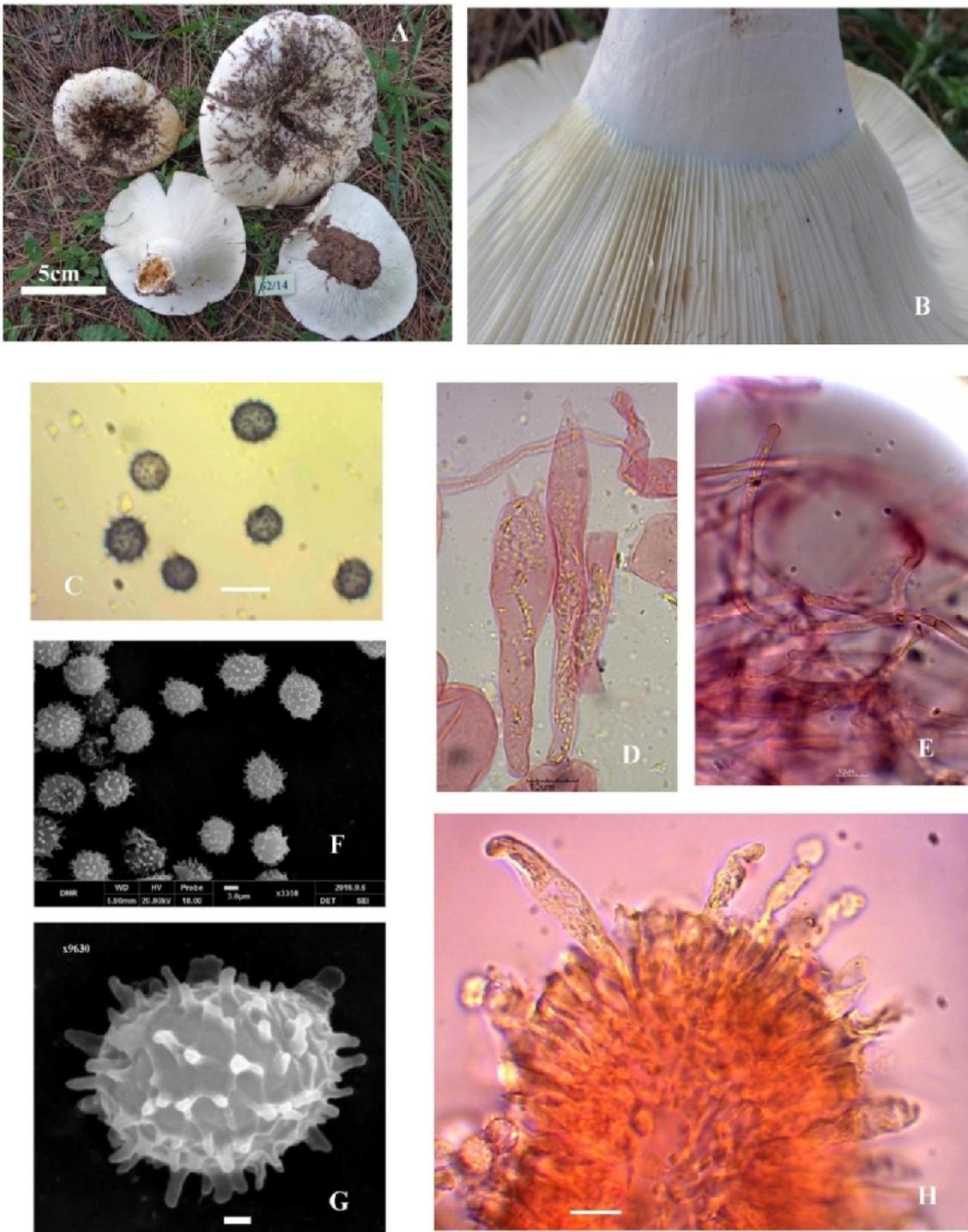
germ pore absent, cyanophilic and amyloid, spore deposit white. Basidia  $(34.2)44.7\text{--}(52.0) \times (6.0)10.3\text{--}(12.1) \mu\text{m}$  ( $Q=4.3$ ), clavate, 2,4-spored, sterigmata up to  $6.0 \times 2.2 \mu\text{m}$ , thin walled, oil globule in some, clamp connections absent. Pleurocystidia present  $(59.5)72.3\text{--}(90.3) \times (8.1)9.3\text{--}(11.9) \mu\text{m}$ , cheilocystidia present  $(33.1)49.4\text{--}(67.2) \times (6.1)7.1\text{--}(9.0) \mu\text{m}$ . Hymenophoral trama  $(1.9)2.4\text{--}(2.7) \mu\text{m}$ . Pileipellis  $(1.7)3.0\text{--}(3.7) \mu\text{m}$ , pileus cystidia  $(33.1)40.2\text{--}(44.6) \times (3.5)3.9\text{--}(4.6) \mu\text{m}$ .

**Collection examined:** India- Himachal Pradesh- Shimla-Narkanda- Oddi: alt. 2621 m a.s.l.; GPS  $32^{\circ}9'52''\text{N } 76^{\circ}16'39''\text{E}$ , scattered growing on soil under leaf litter, coniferous forest, Pine community. Shilpa Sood, DMR Acc. No. 52/14, September 21, 2014.

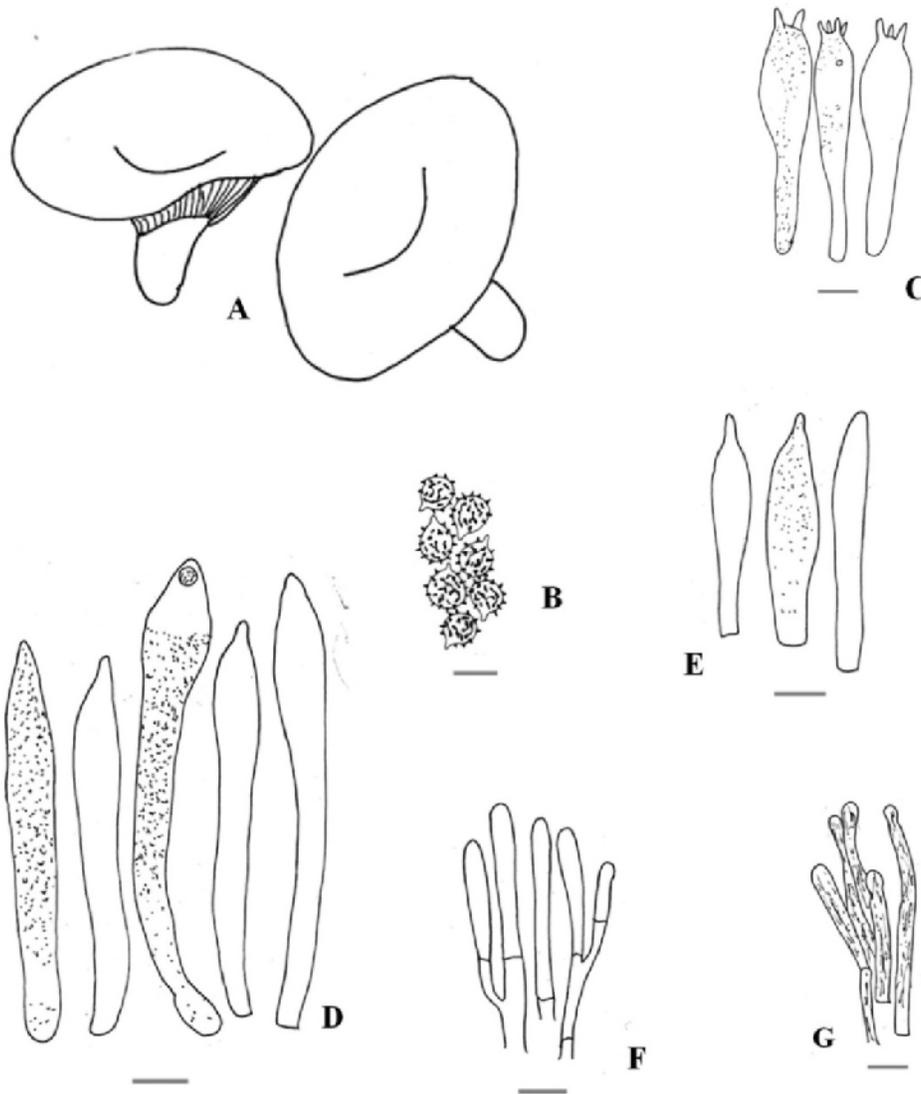
**Discussion.** Present collection belongs to *R. brevipes* var. *acrior*. It is characterized by its white infundibuliform pileus surface with brownish patches in older specimen, unpeeling cuticle, acrid taste, unequal crowded and yellowish white with bluish tinge around the stipe, solid stipe and basidiospores with incomplete reticulum. These features are in conformity with the

details given by Shaffer, (1964) for *R. brevipes* var. *acrior*. Earlier this fungus was reported from India by (Bhatt *et al.*, 1995; Atri *et al.*, 1997; Das and Sharma,

(2005). In the present study, specimen was found in mixed coniferous forest under Pine tree.



**Fig. 11 (A–H) *Russula brevipes* var. *acrior*:** A) Basidiocarps; B) Basidiocarp showing bluish ring around the stipe apex near gills; C) Basidiospores in light microscope; D) Basidia and pleurocystidia; E) Pileipellis; F and G) Basidiospores in SEM; H) Cheilocystidia. Scale bars: C–E and H=10  $\mu$ m; F= 3 $\mu$ m; G=1  $\mu$ m.



**Fig. 12 (A–G) *Russula brevipes* var. *acrior*:** A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis; G) Pileus cystidia. Scale bars: B–G=10 µm.

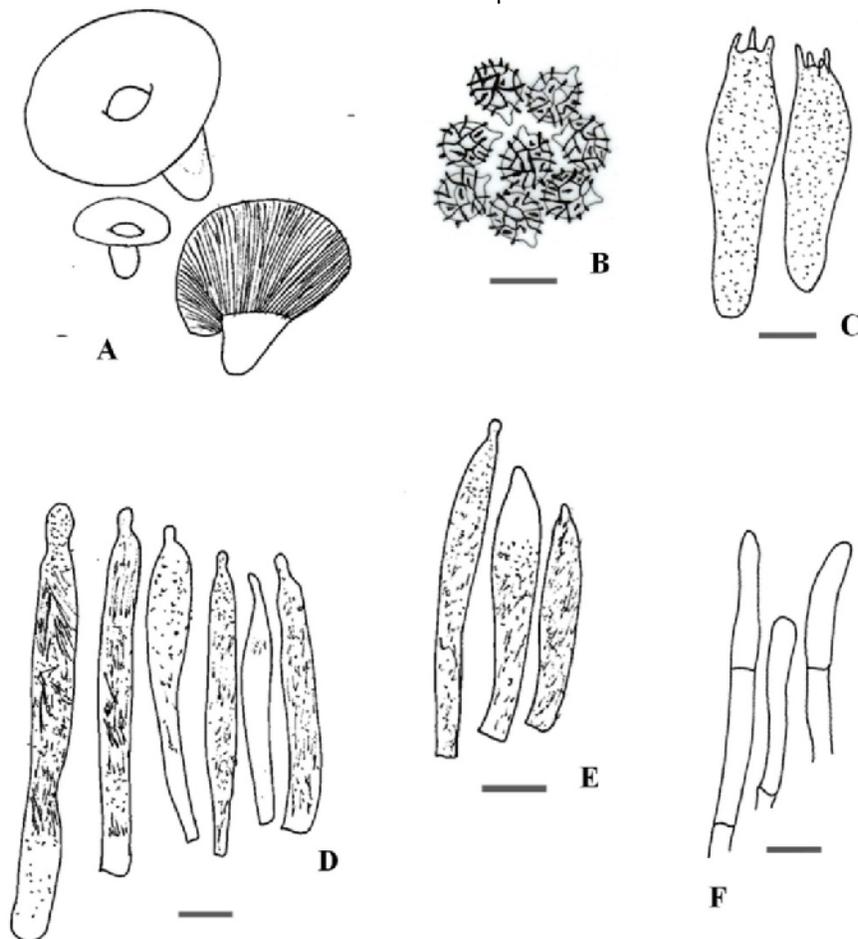
*Russula delica* Fr., *Epicrisis Systematis Mycologici*: 350, 1838 [Figs. 13 (A–D) and 14 (A–F)]

Pileus diameter up to 10.5 cm wide, initially convex with a depression in the centre or infundibuliform at maturity, initially white but developing colour greyish orange (5B-5/5B-4), surface non hygrophanous, margin irregular, non-striate, glabrous, inflexed, moist, cuticle half peeling, pileus consistency fleshy, context colour white up to 1.0 cm thick, no colour change on touch or handling and confluent pileus separation. Lamellae decurrent, white, sub distant, fleshy, gill length 4.6 cm, unequal present in 6 sets of lamellulae, forked, separable. Stipe central, white, cylindrical to clavate 3.5 × 3.0–3.5 cm, glabrous, stuffed then hollow, fleshy, stipe trama white.

Basidiospores (8.9)9.9–(10.8) × (6.2)7.7–(9.3) µm (Q=1.3), hyaline, verrucose, globose, thick walled, apiculate (1.3–1.8 µm), germ pore absent, oil globule present, cyanophilic and amyloid, spore deposit white. Basidia (31.7)39.0–(48.1) × (7.5)10.2–(14.1) µm (Q=3.8), clavate, 4-spored, sterigmata up to 8.3 × 1.8 µm, thin walled, oil globule absent, basal septa without clamps. Pleurocystidia present (35.9)63.2–(94.5) × (4.7)6.3–(9.5) µm, cheilocystidia present (30.0)44.8–(58.6) × (4.8)5.6–(8.2) µm, oil globule absent, clamp connections absent. Pileipellis (2.8)3.4–(4.1) µm. Hymenophoral trama consists of (14.6)20.2–(25.0) × (10.7)15.7–(24.7) µm thick sphaerocysts cells and connective hyphae. Subhymenium 18–22 µm. Hymenium 45–50 µm. Stipitopellis (1.5)2.0–(2.6) µm.



**Fig. 13 (A–D) *Russula delica*:** A and B) Basidiocarps in natural habitat; C and D) Basidiospores in SEM. Scale bars: C and D=1 μm.



**Fig. 14 (A–F) *Russula delica*:** A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis. Scale bars: B–F=10 μm.

**Collection examined:** India- Himachal Pradesh- Solan-Kasauli: alt. 1927 m a.s.l.; GPS 30°53'56" N 76°57'53" E, coniferous forest, solitary among grasses and dried Pine needles under the canopy of *Pinus roxburghii*. Shilpa Sood, DMR Acc. No. 44/15, August 02, 2015.

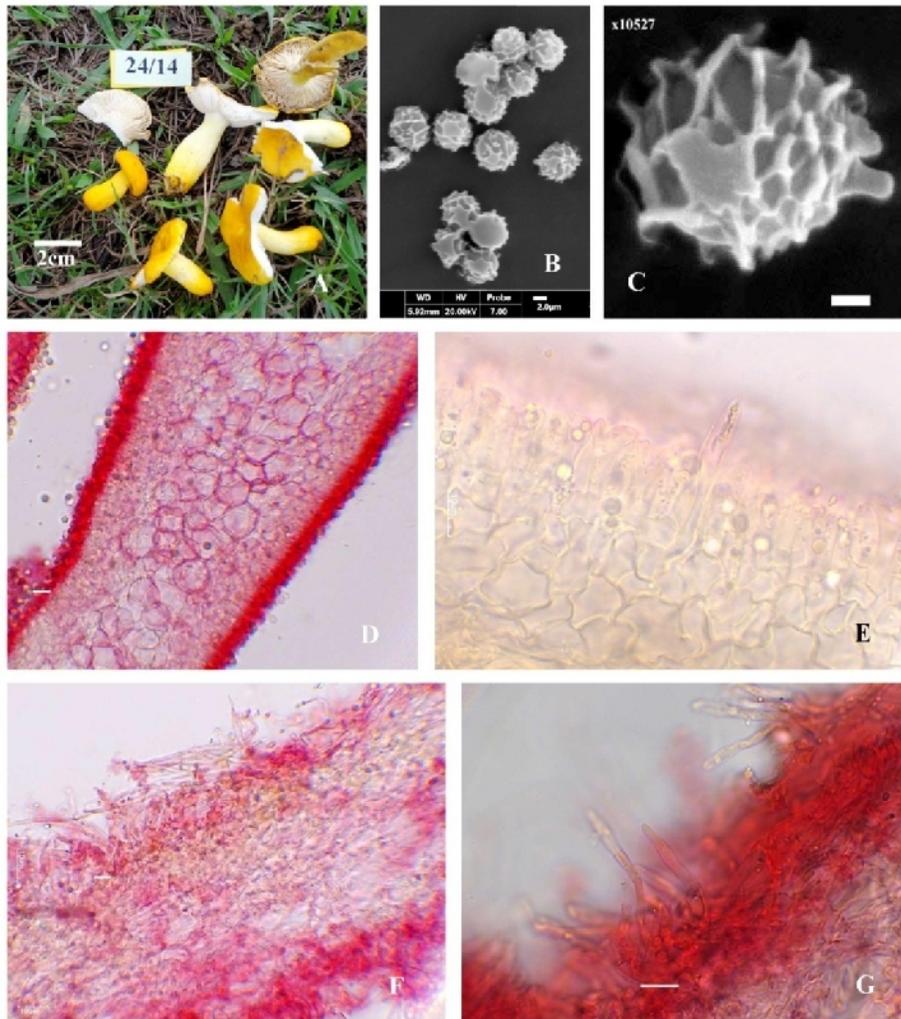
**Discussion.** The above examined collection has been identified as *R. delica* Fr. (1838). It resembles to *R. brevipes* and *R. romagnesiana* in its morphological details. *R. romagnesiana* (Shaffer, 1970) is a small spored ( $4.3\text{--}7.0 \times 5.0\text{--}5.7 \mu\text{m}$ ) mushroom and possesses incrustated pileus hyphae and occasional inamyloid blunt warts which have a characteristic feature. As compared to the spores of *R. delica* and *R. brevipes* measures from  $8.0\text{--}10.8 \times 6.7\text{--}9.8 \mu\text{m}$  excluding ornamentation which measure from  $0.4\text{--}1.0 \mu\text{m}$  in *R. delica* and  $0.7\text{--}1.7 \mu\text{m}$  in *R. brevipes* (Shaffer, 1970). Beside this *R. brevipes* has more crowded gills and a faint bluish-green band around the top of the stem where the gills terminate. From India *R. delica* is reported from Jammu and Kashmir, Himachal Pradesh and Uttarakhand (Saini and Atri, 1984; Saini *et al.*,

1988; Atri and Saini, 1986). In the present study this is reported from coniferous forest in the lower hills of Himalayas under *Pinus roxburghii*.

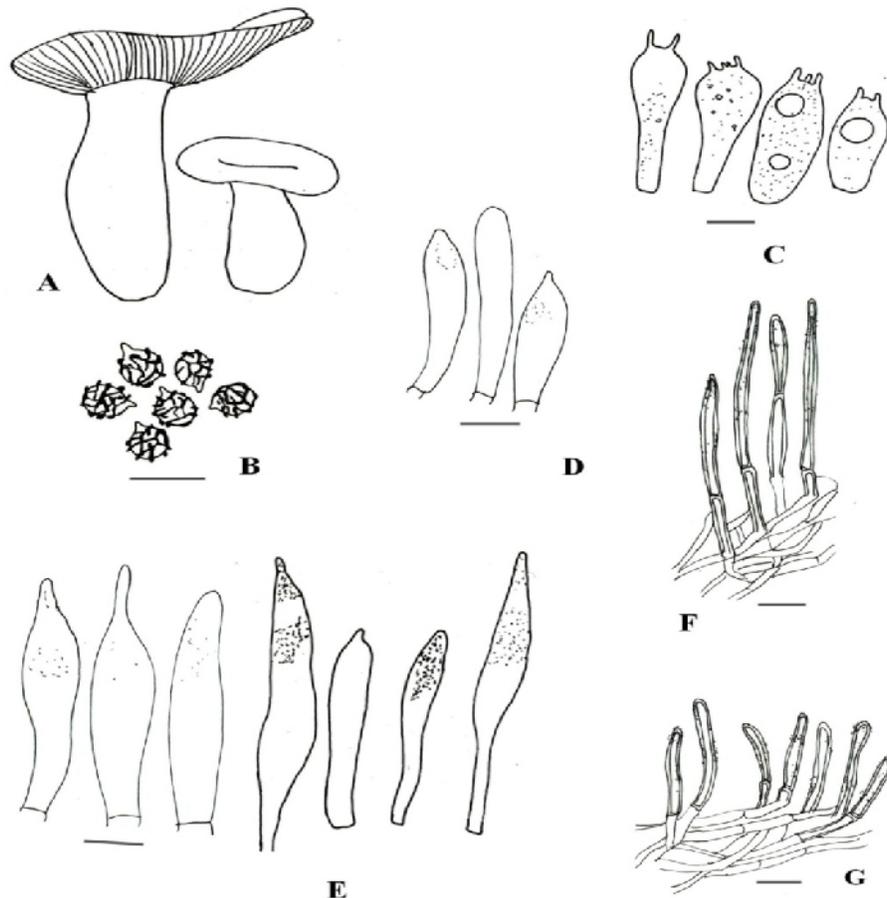
*Russula flavida* Frost, Annual Report on the New York State Museum of Natural History 32: 32, 1880

[Figs. 15 (A–G) and 16 (A–G)]

Pileus diameter up to 4.6 cm wide, shallowly depressed, young basidiomata yolk (4B-8) colour, margin banana yellow (4A-4), deep yellow (4A-8) to yolk yellow (4B-8) in mature basidiomata, surface non hygrophanous, regular, inflexed, non-striate, moist, glabrous, scales absent, cuticle half peeling, pileus consistency fleshy, context colour white, upto 0.2 cm thick, no colour change on touch or handling and confluent pileus separation. Lamellae adnexed, equal, subdistant, white to light brown, fleshy, separable, gill size  $1.5 \times 0.2 \text{ cm}$ . Stipe central, equal  $3.0 \times 0.6\text{--}1.0 \text{ cm}$ , amber yellow (4A-6) to deep yellow (4A-8), in mature specimen colour of upper part fades to light yellow to white, terete in cross section, blunt, smooth, hollow, fleshy.



**Fig. 15 (A–G) *Russula flavida*:** A) Basidiocarps in natural habitat; B and C) Basidiospores in SEM; D) Section of gill; E) Hymenium with pleurocystidia; F) Pileipellis; G) Stiptopellis. Scale bars: B= 2µm; C=1 µm; D–G=10 µm.



**Fig. 16 (A–G) *Russula flavida*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Cheilocystidia; E) Pleurocystidia; F) Pileipellis; G) Stipitopellis. Scale bars: B–G=10  $\mu$ m.**

Basidiospores (6.7)7.5–(8.2)  $\times$  (4.8)5.5–(6.2)  $\mu$ m (Q=1.4), sub-globose, ornamented, apiculate (0.7–1.5  $\mu$ m), germ pore absent, oil globule present, cyanophilic and amyloid, in SEM studies ornamentation amyloid, up to 0.8  $\mu$ m, completely interconnected by irregular lines and low ridges, forming a partial to nearly complete reticulum, suprahilar area slightly depressed spore deposit creamish white. Basidia (21.3)24.0–(27.5)  $\times$  (7.2)8.6–(10.3)  $\mu$ m (Q=2.8), clavate, 2,4-spored, sterigmata 3.8  $\times$  1.2  $\mu$ m, thin walled, oil globule present, basal septa without clamp connections. Pleurocystidia present (33.8)51.8–(62.8)  $\times$  (4.9)6.5–(9.6)  $\mu$ m, cheilocystidia present (29.8)37.6–(45.2)  $\times$  (4.2)5.6–(7.5)  $\mu$ m. Pileipellis composed of sub erect to erect, encrusted hyphae, aggregated into fascicles and differentiated thick walled, cylindrical, cystidia with encrustations (1.8)3.0–(4.2)  $\mu$ m in diam. Hymenophoral trama sphaerocysts and connective hyphae present, laticifer hyphae absent. Subhymenium 20–25  $\mu$ m. Hymenium 15–27  $\mu$ m, single cell 8–15  $\mu$ m. Stipitopellis consists of horizontal to erect interwoven hyphae (2.1)3.0–(3.8)  $\mu$ m, septate, branched and encrusted like pileipellis

encrustations yellow to yellowish brown in KOH, clamp connections absent.

**Collection examined:** India- Himachal Pradesh- Palampur- Chamatu: alt. 1215 m a.s.l.; GPS 32°9'53"N 76°16'39"E, solitary, growing among grasses under the canopy of *Pinus roxburghii*. Shilpa Sood, DMR Acc. No. 24/14, September 13, 2014.

**Discussion.** The above examined collection goes well with the description of *R. flavida*. Macroscopically, this species is characterized by its bright yellow to orange yellow colour, dry, velvety pileus and usually small to medium sized stipe. Its most obvious microscopic features are the non-fuchsinophilic, incrusting pigments of the cuticular hyphae, dermatocystidia with refringent, composed of slightly thickened walls and reticulate spore ornamentation. *R. ochroleuroides* Kauffman is a similar species and the only members of the subsection to have extracellular incrusting pigments. *R. ochroleuroides* has nearly white stipe, bitter to acrid taste, and usually a larger, dull yellow pileus. From India, it was already reported from Uttarakhand (Das *et al.*, 2002; Sembal *et al.*, 2019) and first time reported from Himachal Pradesh.

*Russula fellea* (Fr.) Fr., Stirpes agri Femsionensis: 57 (1825) [Figs. 17 (A–F) and 18 (A–G)]

Pileus diameter up to 5.0 cm wide, convex with slight depression, lemon yellow (3D-8), slightly paler towards margin, surface non hygrophanous, margin irregular, striate, glabrous, scales absent, glutinous, shiny when moist, cuticle half peeling, pileus consistency fleshy, context light yellow, up to 0.4 cm thick, no colour change on touch or handling and non confluent pileus separation. Lamellae adnate, yellowish white to cream yellow, fleshy, gill size  $2.5 \times 0.6$  cm equal, subdistant, equal, separable, gill edge smooth and fragile. Stipe central, dull yellow (3B-3) to cream yellow, cylindrical  $3.5 \times 1.1$ – $2.0$  cm, terete, glabrous, hollow, fleshy, stipe trama light yellow, no colour change on bruising, ring, veil and volva absent.

Basidiospores  $(7.9)8.5$ – $(9.3) \times (5.8)6.2$ – $(8.4) \mu\text{m}$  ( $Q=1.1$ – $1.3$ ), hyaline, ornamented, subglobose to ellipsoidal, apiculate ( $0.9$ – $1.3 \mu\text{m}$ ), germ pore absent, oil globule present, cyanophilic and amyloid, spore deposit cream. Basidia  $(17.9)23.0$ – $(27.2) \times (9.1)11.1$ – $(13.2) \mu\text{m}$  ( $Q=2.1$ ), clavate, 2,4- spored, sterigmata up to  $4.4 \times 1.8 \mu\text{m}$ , thin walled, oil globule absent, basal septa without clamps. Pleurocystidia present  $(21.2)56.2$ – $(78.9) \times 7.5)8.9$ – $(10.8) \mu\text{m}$  fusiform to cylindrical, cheilocystidia present  $(26.5)32.0$ – $(45.7) \times (5.4)7.1$ – $(9.5) \mu\text{m}$  same as pleurocystidia, oil globule absent, clamp connections absent. Pileipellis  $2.5$ – $3.7 \mu\text{m}$ , pileus cystidia present, abundant, cylindrical to sub club shaped  $3.6$ – $7.7 \mu\text{m}$ . Hymenophoral trama  $(17.1)24.6$ – $(34.2) \times (11.4)19.6$ – $(26.9) \mu\text{m}$  thick sphaerocysts with connective hyphae. Hymenium  $20$ – $25 \mu\text{m}$ .



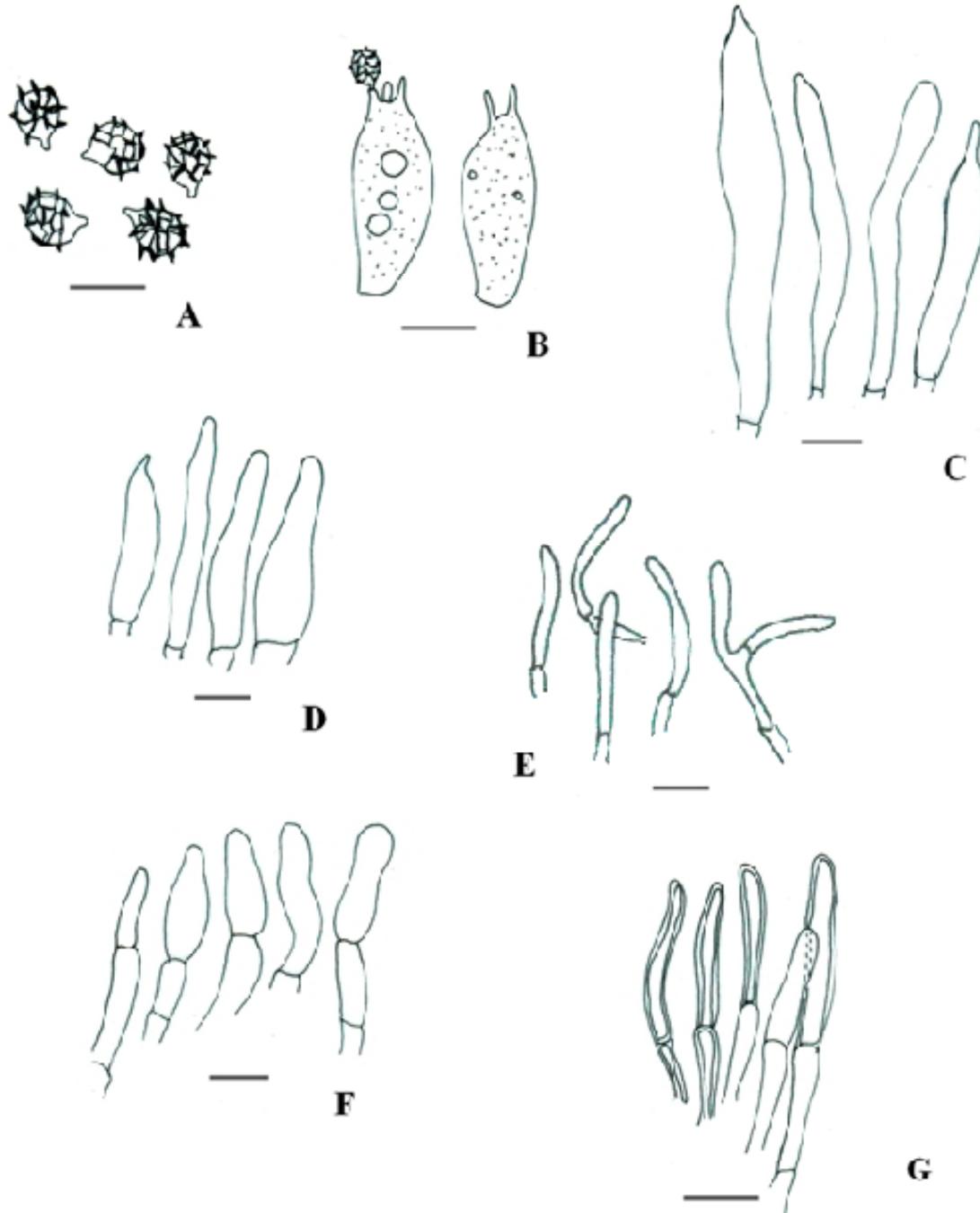
Fig. 17 (A–F) *Russula fellea*: A and B) Basidiocarps in natural habitat; C) Pileus surface; D) Gill attachment; E and F) Basidiospores in SEM. Scale bars: E=  $3 \mu\text{m}$ ; F=  $0.9 \mu\text{m}$ .

*Stipitopellis* (2.2)2.9–(3.4)  $\mu\text{m}$ , stipe cystidia cylindrical, septate 2.3–4.2  $\mu\text{m}$ .

**Collection examined:** India- Himachal Pradesh- Solan-Kasauli: alt. 1927 m a.s.l.; GPS 30°53'56" N 76°57'53" E, coniferous forest, Pine community, on soil among grasses and leaf litter. Shilpa Sood, DMR Acc. No. 45/15, August 02, 2015.

**Discussion.** This genera is identified by pileus surface sticky to gelatinous, margins tuberculate striate, basidiospores having isolated warts on the surface which often connect to form partial network on the

surface of spore, pileus cuticle with pileocystidia. This taxa is already documented by workers from Punjab, Utharakhand, Sikkim, Kerala (Atri *et al.*, 2010; Das and Sharma, 2005; Das *et al.*, 2010, 2013; Varghese *et al.*, 2010; Pradeep and Vrinda, 2007, 2010; Mohanan, 2011; Manimohan and Deepna Latha, 2011; Farook *et al.*, 2013). This species is confused with *R. ochroleuca*. The spore size of *R. ochroleuca* is small 5.0–8.6  $\times$  4.3–8.6  $\mu\text{m}$ . It constitutes a new record for Himachal Pradesh.



**Fig. 18 (A–G) *Russula fellea*:** A) Basidiospores; B) Basidia; C) Pleurocystidia; D) Cheilocystidia; E) Pileipellis; F) Pileus cystidia; G) Stipe cystidia. Scale bar: A–G=10  $\mu\text{m}$ .

*Russula foetens* Pers., *Observationes mycologicae* 1: 102, 1796 [Figs. 19 (A–D) and 20 (A–G)]

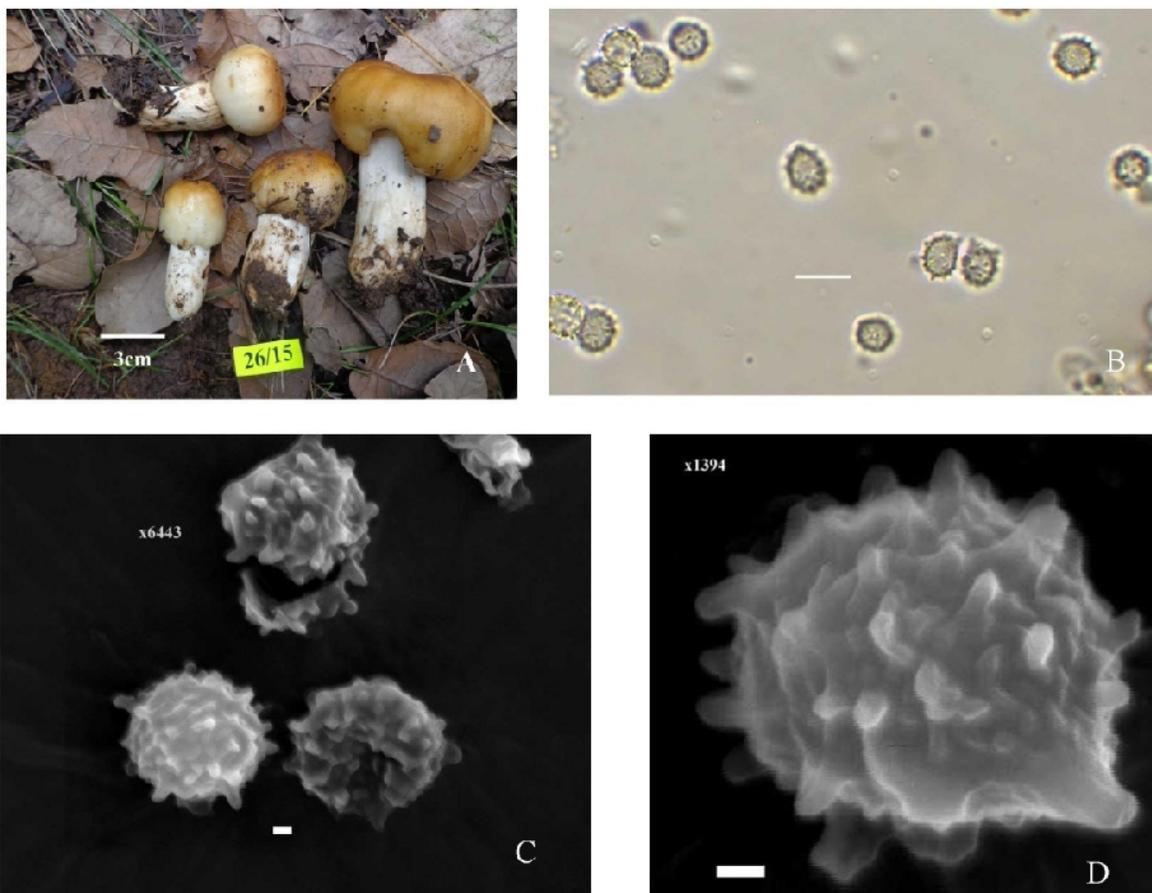
Pileus diameter up to 6.7 cm wide, slightly depressed, deep yellow (4C-8) center, greyish yellow (4C-5) to champagne (4B-5) margin, surface non hygrophanous, margin regular, striate, glabrous, scales absent, inflexed, glutinous, cuticle half peeling, pileus consistency fleshy, context colour white, up to 0.5 cm thick, no colour change on touch or handling and confluent pileus separation. Lamellae adnexed, white, subdistant, fleshy, interveined, gill thickness 0.6 cm unequal present in 3 sets of lamellulae. Stipe central, white, cylindrical  $8.5 \times 2.8$  cm, terete, glabrous, context stuffed, fleshy, stipe surface white, stipe trama white.

Basidiospores  $(7.9)8.8\text{--}(9.4) \times (6.0)6.6\text{--}(7.2) \mu\text{m}$  ( $Q=1.3$ ), hyaline, warted, globose, apiculate ( $0.7\text{--}1.8 \mu\text{m}$ ), germ pore absent, oil globule present, cyanophilic and amyloid. Basidia  $(40.1)51.4\text{--}(60.3) \times (10.3)11.8\text{--}(12.7) \mu\text{m}$  ( $Q=4.4$ ), clavate, 4-spored, sterigmata up to  $5.6 \times 1.9 \mu\text{m}$ , thin walled, oil globule present, clamp connections absent. Pleurocystidia present  $(49.0)57.8\text{--}(68.2) \times (6.1)8.8\text{--}(11.8) \mu\text{m}$ , chilocystidia present  $(27.7)33.9\text{--}(44.0) \times (4.4)6.4\text{--}(7.7) \mu\text{m}$ , oil globule absent, clamp connections absent, pseudocystidia deep seated in the subhymenium  $(44.9)56.9\text{--}(68.8) \times$

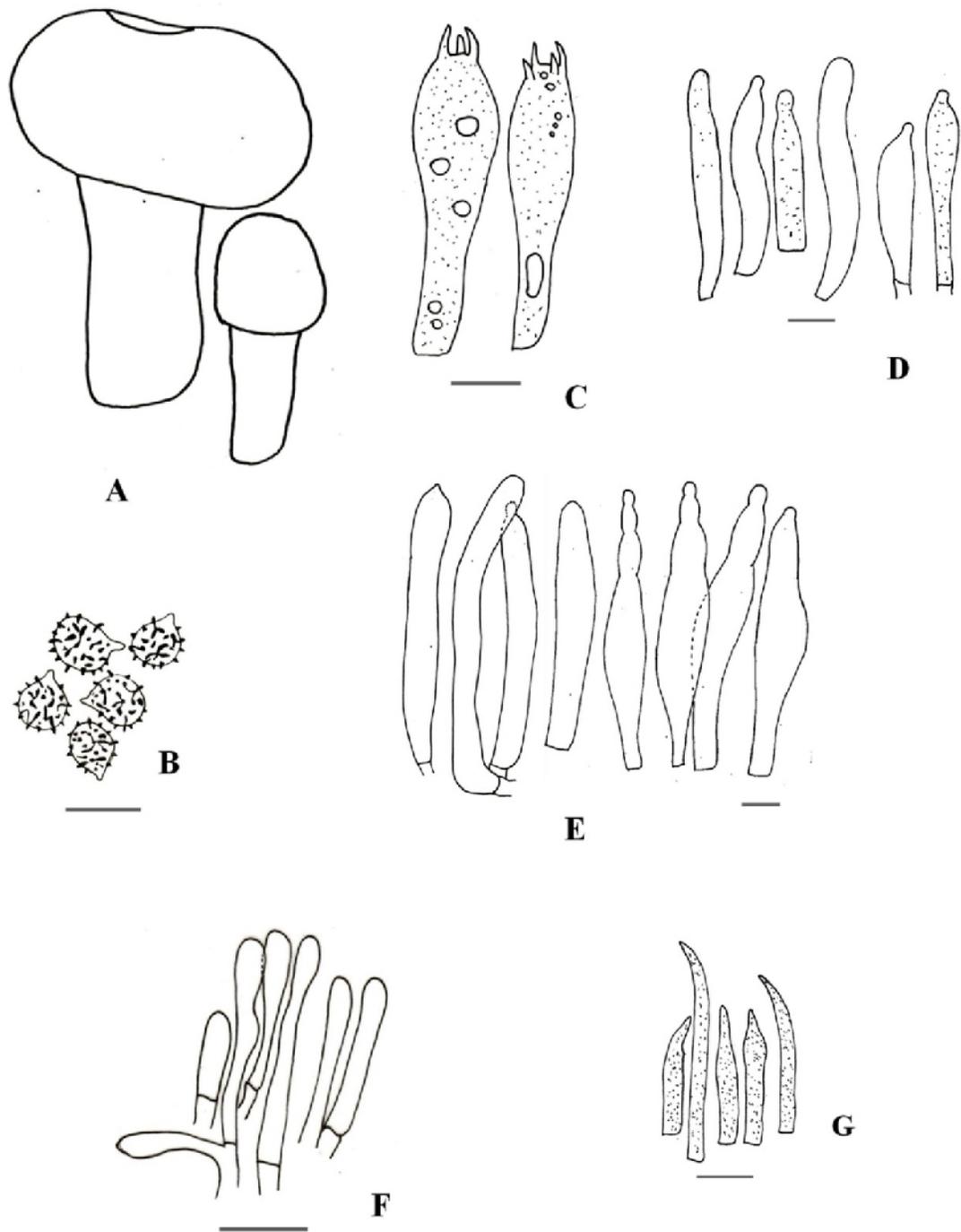
$(5.5)8.1\text{--}(10.9) \mu\text{m}$ . Pileipellis  $(2.1)2.4\text{--}(2.9) \mu\text{m}$ . Hymenophoral trama composed of sphaerocysts and connective hyphae. Subhymenium  $11\text{--}15 \mu\text{m}$ . Hymenium  $31\text{--}35 \mu\text{m}$ . Stipitopellis  $(4.5)5.8\text{--}(8.0) \mu\text{m}$  made up of irregularly arranged hyphae, stipe trama made up to spherocytes.

**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l.; GPS  $31^{\circ}6'0''\text{N}77^{\circ}15'0''\text{E}$ , mixed forest, Oak community, among grasses and leaf litter. Shilpa Sood, DMR Acc. No. 26/15, July 26, 2015.

**Discussion.** *R. foetens* is the type species of subgenus *Ingratula* Romagnesi characterised by sticky to gelatinous pileus surface, margins tuberculate striate, basidiospores having isolated warts on the surface which often connect to form partial network on the surface of spore, pileus cuticle with pileocystidia with pointed ends. All the details of the fungus go well with description given by (Romagnesi, 1967; Rayner, 1970; Sarnari, 1998). The closely related *R. laurocerasi* and *R. Subfoetens*. *R. laurocerasi* paler in colour and somewhat less repulsive in odour, apparently more common in conifer forests. From India it is reported from Jammu and Kashmir and Uttarakhand: Saini and Atri, (1984), Himachal Pradesh: Saini and Atri, (1981).



**Fig. 19 (A–D) *Russula foetens*:** A) Basidiocarps; B) Basidiospores in light microscope; C and D) Basidiospores in SEM. Scale bars: B=10  $\mu\text{m}$ ; C=1  $\mu\text{m}$ ; D=0.8  $\mu\text{m}$ .



**Fig. 20 (A–G): *Russula foetens*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Cheilocystidia; E) Pleurocystidia; F) Pileipellis; G) Pileus cystidia. Scale bars: B–G=10  $\mu$ m.**

*Russula fragilis* Fr., Stirpes agri Femsionensis: 57, 1825 [Figs. 21 (A–F) and 22 (A–F)]

Pileus diameter up to 6.0 cm wide, convex to plane, dark violet (16F-8) center, pastel violet (16A-4) to lilac (16B-3) margin, surface non hygrophanous, margin regular, striate, inflexed, glutinous, glabrous, scales absent, cuticle half peeling, pileus consistency fleshy, context white, up to 0.3 cm thick, no colour change on touch or handling and confluent pileus separation.

Lamellae adnate, subdistant, white, fleshy, separable, inter veined, gill size 3.5  $\times$  0.7 cm equal, gill edges entire, forked, no colour change on bruising. Stipe central, white, cylindrical 5.0  $\times$  1.0 cm, terete in cross section, blunt at the base, hollow, glabrous, stipe trama white, unchanging when cut or bruised, fleshy.

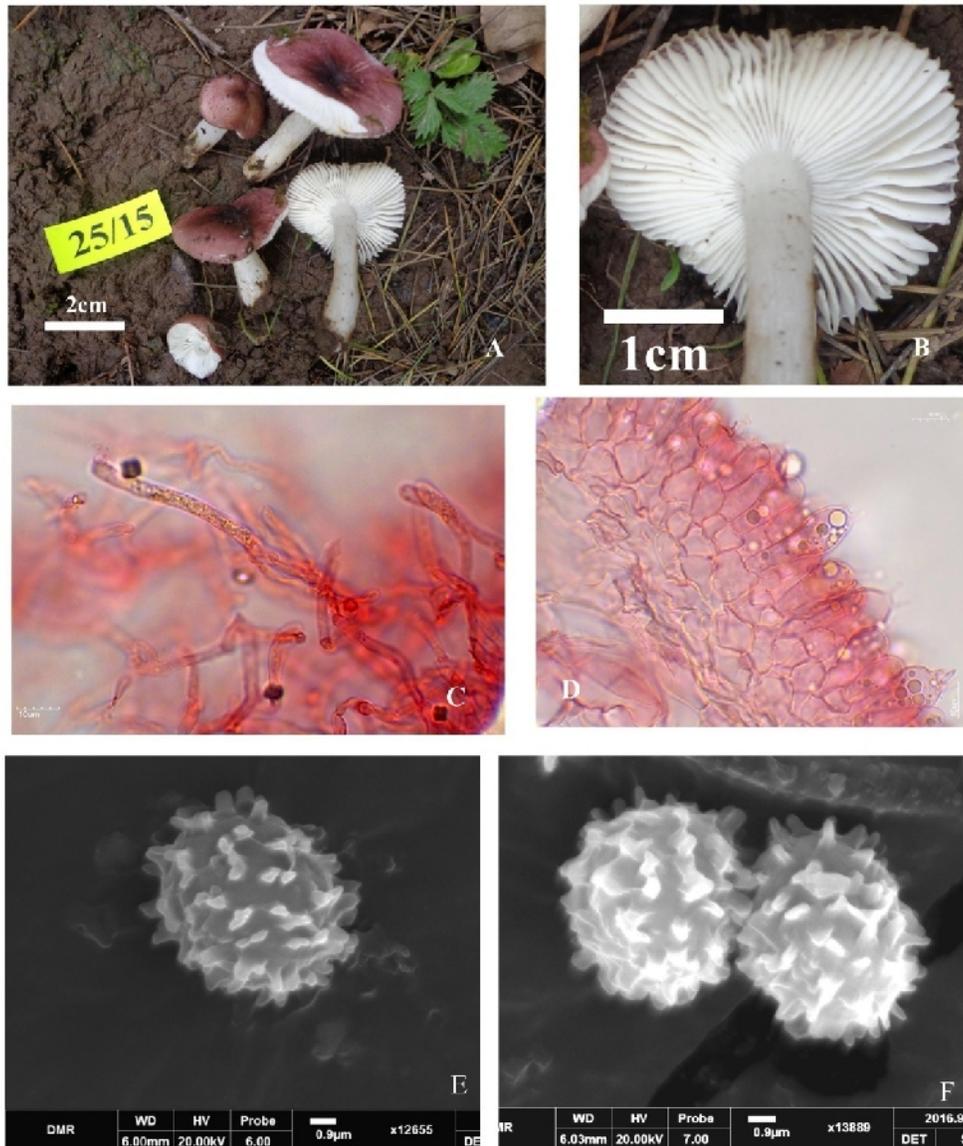
Basidiospores (8.5)8.8–(9.4)  $\times$  (5.9)6.5–(7.7)  $\mu$ m (Q=1.2–1.3), hyaline, warty, sub-globose to sub elliptical, apiculate (0.5–0.8  $\mu$ m), germ pore absent, oil

globule present, cyanophilic and amyloid, in SEM occasionally isolated, mostly connected by fine to heavy lines, 2–3 catenate sometimes forming short ridges, spore deposit white. Basidia (22.6)27.1–(34.2) × (8.3)9.8–(10.9)  $\mu\text{m}$  (Q=2.8), clavate, 2,4-spored, sterigmata up to 6.1 × 2.0  $\mu\text{m}$ , thin walled, oil globule present, basal septa without clamps. Pleurocystidia (38.4)49.2–(60.8) × (5.1)8.3–(13.0)  $\mu\text{m}$ , cheilocystidia (27.1)31.3–(36.5) × (4.7)6.6–(8.9)  $\mu\text{m}$ , oil globule absent, clamp connections absent. Pileipellis (2.0)2.4–(3.6)  $\mu\text{m}$ , ixotrichoderm, pileocystidia (29.6)36.4–(46.3) × (3.8)4.4–(6.0)  $\mu\text{m}$ , clavate to cylindrical. Hymenophoral trama (14.0)24.8–(32.1) × (10.7)19.6–(27.7)  $\mu\text{m}$  thick sphaerocysts with rare hyphae, laticifer hyphae absent. Subhymenium 21–28  $\mu\text{m}$ , single cell 4–13  $\mu\text{m}$ . Hymenium 21–30  $\mu\text{m}$ . Stipitopellis (2.0)2.8–

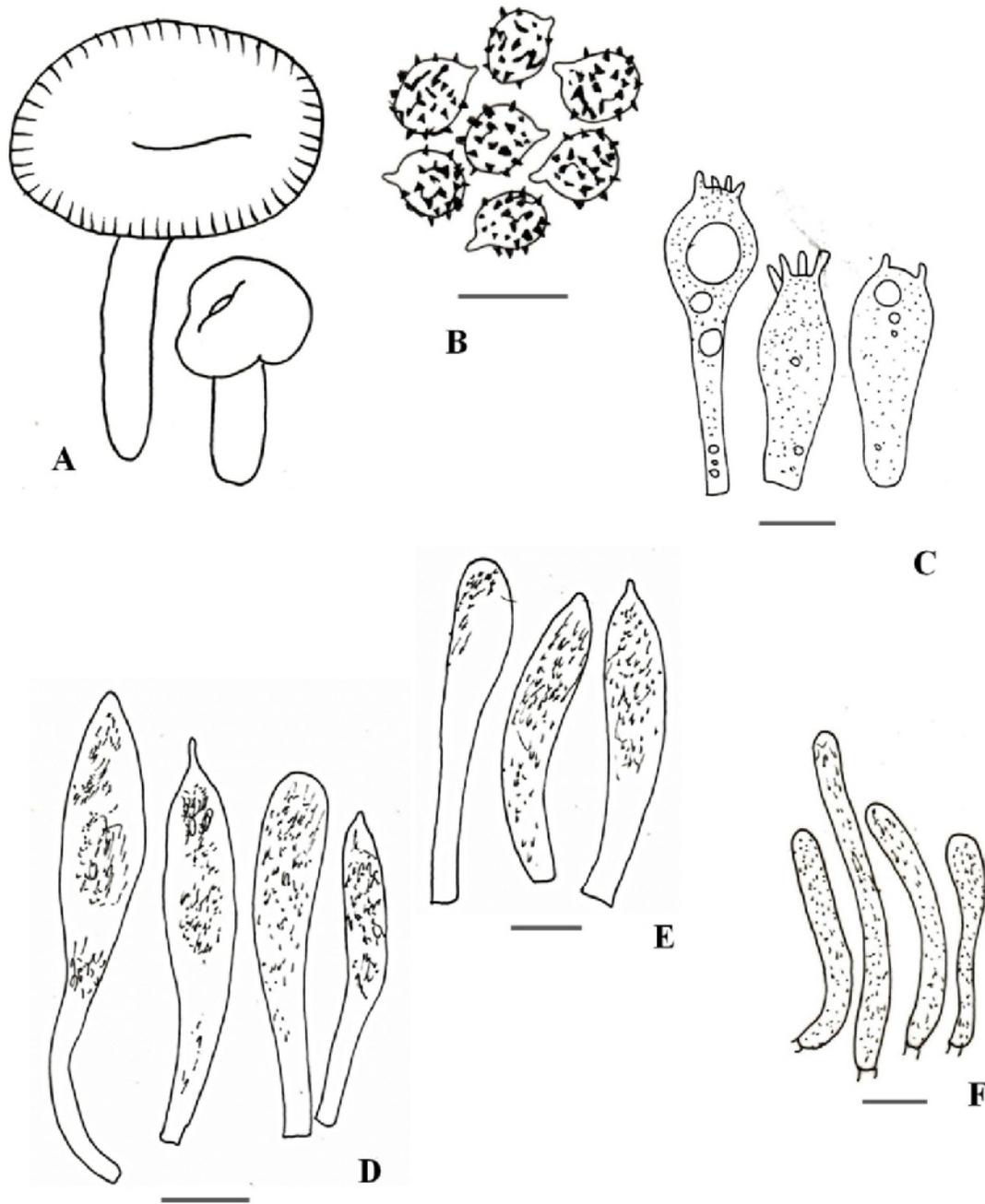
(3.9)  $\mu\text{m}$ , made up of irregularly arranged ixocutis with upright hyphae.

**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l.; GPS 31°6'0"N77°15'0"E, coniferous forest, Pine community, on soil. Shilpa Sood, DMR Acc. No. 25/15, July 26, 2015.

**Discussion.** The present collection belongs to *R. fragilis*. The characteristic features of the present collection are convex, then flattening or depressed, variable in colour purple or violet-tinted and rather pale, or purplish-red, purple-violet, with a darker centre. It grows on or near wood, generally purple and dull green colours, white to creamy-white spores and clavate pileocystidia are diagnostic for *R. fragilis*. *R. atropurpurea* and *R. aquosa* are closely related species.



**Fig. 21 (A–F) *Russula fragilis*:** A) Basidiocarps; B) Gill attachment; C) Pileipellis with cystidia; D) Section of gill; E and F) SEM of basidiospores. Scale bars: C and D=10  $\mu\text{m}$ ; E and F= 0.9  $\mu\text{m}$ .



**Fig. 22 (A–F) *Russula fragilis*: A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis. Scale bars: B–F=10  $\mu$ m.**

As compared to *R. atropurpurea* it is more fragile and *R. aquosa* grows in *Sphagnum*. Spores globose, connected by fine lines to form an almost complete network. Cap cystidia cylindrical to club-shaped. Earlier this fungus has been reported from Himachal Pradesh by Saini and Atri, (1984, 1989).

*Russula grisea* Fr., *Epacr. Syst. Mycol.* (Upsaliae): 361, 1838

[Figs. 23 (A–F) and 24 (A–G)]

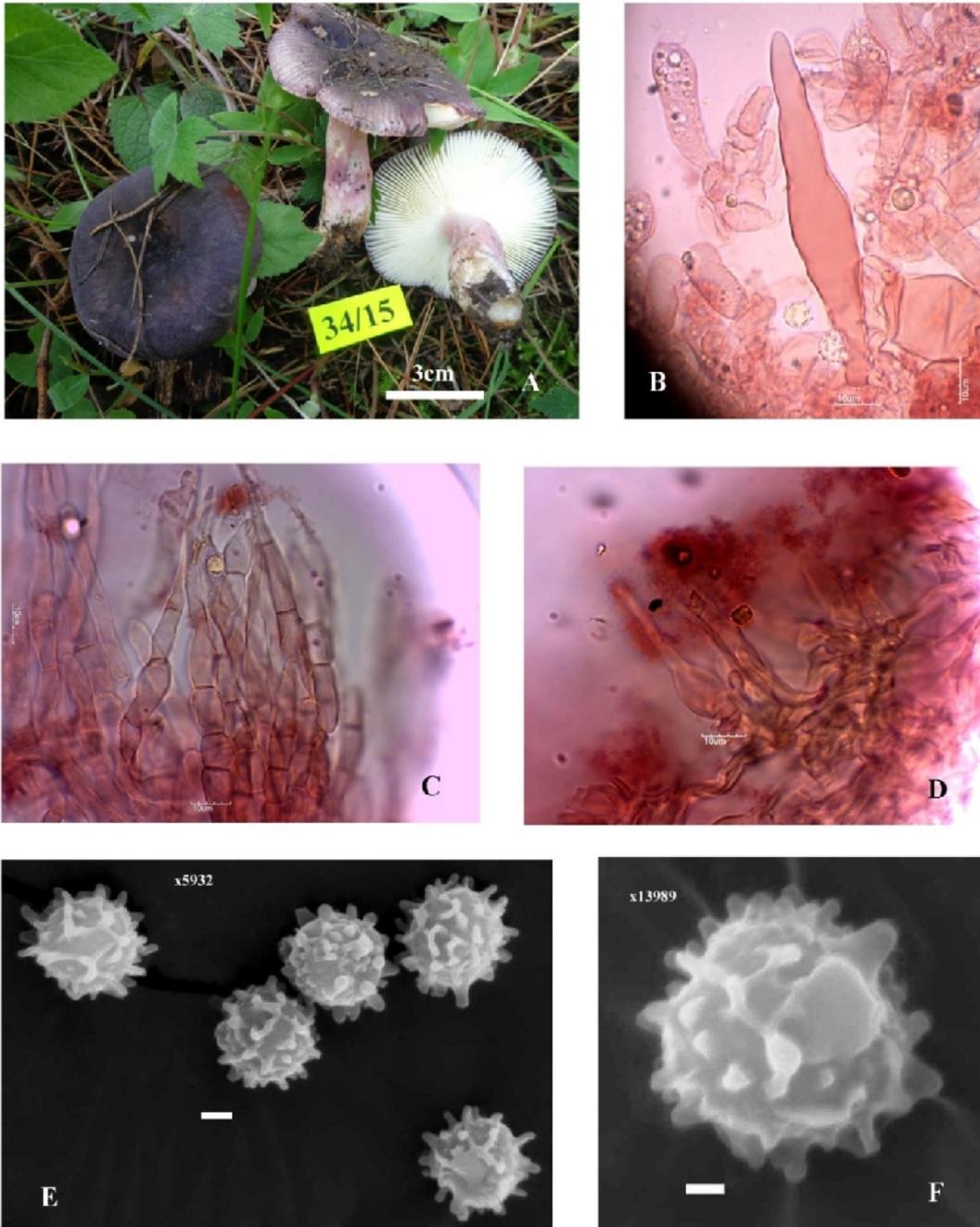
Pileus diameter up to 8.0 cm wide, shallowly depressed, dark purple (15F-4), surface non hygrophanous, margin

irregular, striate, glabrous, scales absent, inflexed, glutinous, cuticle (easily peeled off) half peeling, pileus consistency fleshy, context colour cream, up to 0.4 cm thick, no colour change on touch or handling. Lamellae adnexed, subdistant, white, fleshy, gill size  $3.7 \times 0.4$  cm equal, bifurcating. Stipe central, cream, light lilac (15A-4/15A-5), cylindrical  $8.5 \times 2.8$  cm, terete in cross section, glabrous, hollow, fleshy, stipe trama cream. Basidiospores  $(7.4)7.7\text{--}(8.3) \times (5.2)5.9\text{--}(6.6) \mu\text{m}$  (Q= 1.3), yellow, verrucose, thick walled, apiculate

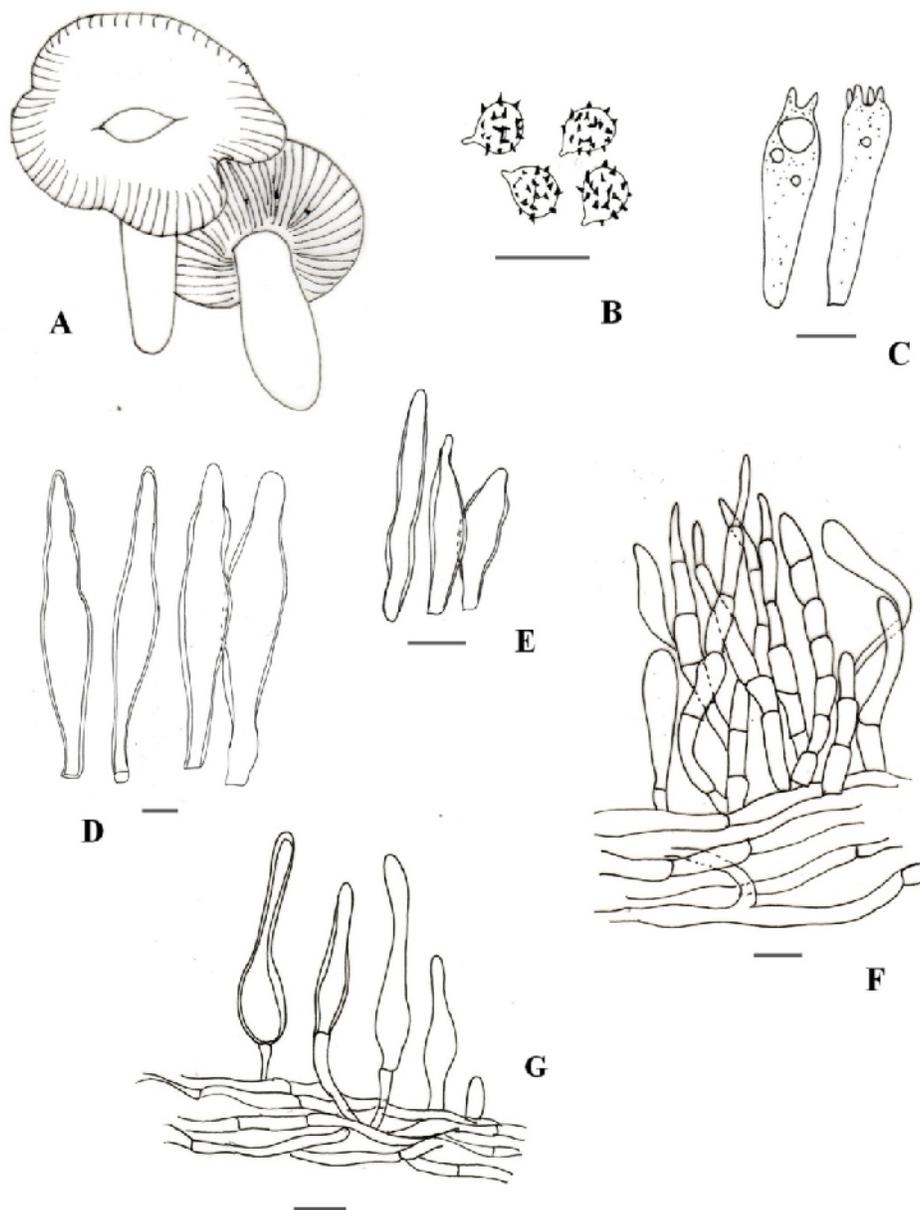
upto  $1.6 \times 1.2 \mu\text{m}$ , germ pore absent, oil globule present, cyanophilic and amyloid, spore deposit white. Basidia  $(29.2)34.6\text{--}(40.2) \times (8.7)9.9\text{--}(11.4) \mu\text{m}$  ( $Q=3.4$ ), clavate, 2,4-spored, sterigmata up to  $3.5 \times 1.8 \mu\text{m}$ , thin walled, oil globule present, basal septa without clamps. Pleurocystidia present  $(76.8)85.3\text{--}(111.1) \times (12.3)14.6\text{--}(19.9) \mu\text{m}$ , cheilocystidia present  $(28.9)38.3\text{--}(45.6) \times (5.3)7.2\text{--}(8.7) \mu\text{m}$ , oil globule absent, clamp connections absent. Pileipellis from the cutis in tufts of slender, multiseptate  $4.9\text{--}7.6 \mu\text{m}$  broad cuticular elements including pileocystidia, septa without clamps. Hymenophoral trama  $(19.7)29.2\text{--}(37.2)$

$\times (19.1)23.9\text{--}(35.7) \mu\text{m}$  thick, consists of sphaerocysts and connective hyphae. Subhymenium  $20\text{--}30 \mu\text{m}$ . Hymenium  $30\text{--}35 \mu\text{m}$ . cuticle consists of longitudinally running septate  $1.7\text{--}3.2 \mu\text{m}$  broad hyphae, cutis arises a tufts of caulocystidia measuring  $(33.7)45.2\text{--}(50.7) \times (3.8)7.0\text{--}(13.3) \mu\text{m}$  in size, context made up of rosettes of sphaerocysts.

**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l.; GPS  $31^{\circ}6'0''\text{N}77^{\circ}15'0''\text{E}$ . 26.07.2015, coniferous forest, Pine community, among grasses. Shilpa Sood, DMR Acc. No. 34/15, July 26, 2015.



**Figs. 23 (A–F) *Russula grisea*:** **A)** Basidiocarps in natural habitat; **B)** Pleurocystidia; **C)** Pileus cystidia; **D)** Stipitocystidia; **E and F)** Basidiospores in SEM. Scale bars: B–D=10  $\mu\text{m}$ ; E=2  $\mu\text{m}$ ; F=0.9  $\mu\text{m}$ .



**Fig. 24 (A–G) *Russula grisea*:** A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis; G) Stipitopellis with cystidia. Scale bars: B–G=10  $\mu$ m.

**Discussion.** The present collection belongs to subgenus *Heterophyllidia* Romagnesi because of its greenish tinged greyish magenta pileus surface, unchanging flesh and presence of dermatocystidia. The examined collection goes well with the description given by Romagnesi, (1967) and Rayner, (1970). The characteristic features of the present collection are its dry, adnexed, distantly spaced forked lamellae, lilac white stipe surface, basidiospores with mostly isolated warts, pleurocystidia with blunt capitate tubular to flame shaped tips and pileus cuticle an ixocutis with multiseptate hyphae intermingled with dermatocystidial elements with capitate to tubular tips. In India, this fungus is already reported from Himachal Pradesh: Atri *et al.*, (1993), Utharakhand: Das and Sharma, (2005).

*Russula subfoetens* W.G. Sm., J. Bot.: 337, 1873

[Figs. 25 (A–G) and 26 (A–G)]

Pileus diameter up to 9.5 cm wide, plano convex centrally depressed, rust brown (6E-8) center, brownish orange (5C-5) margin, surface non hygrophanous, margin regular, striate, glabrous, scales absent, inflexed, glutinous, cuticle half peeling, pileus consistency fleshy, context colour white, up to 0.4 cm thick, no colour change on touch or handling and confluent pileus separation. Lamellae adnexed, white, close, fleshy, separable, gill size  $4.5 \times 0.7$  cm, equal, smooth gill edge. Stipe central, white, cylindrical,  $8.9 \times 2.4$  cm, glabrous, stuffed, fleshy, stipe trama white in colour, no colour change on bruising.

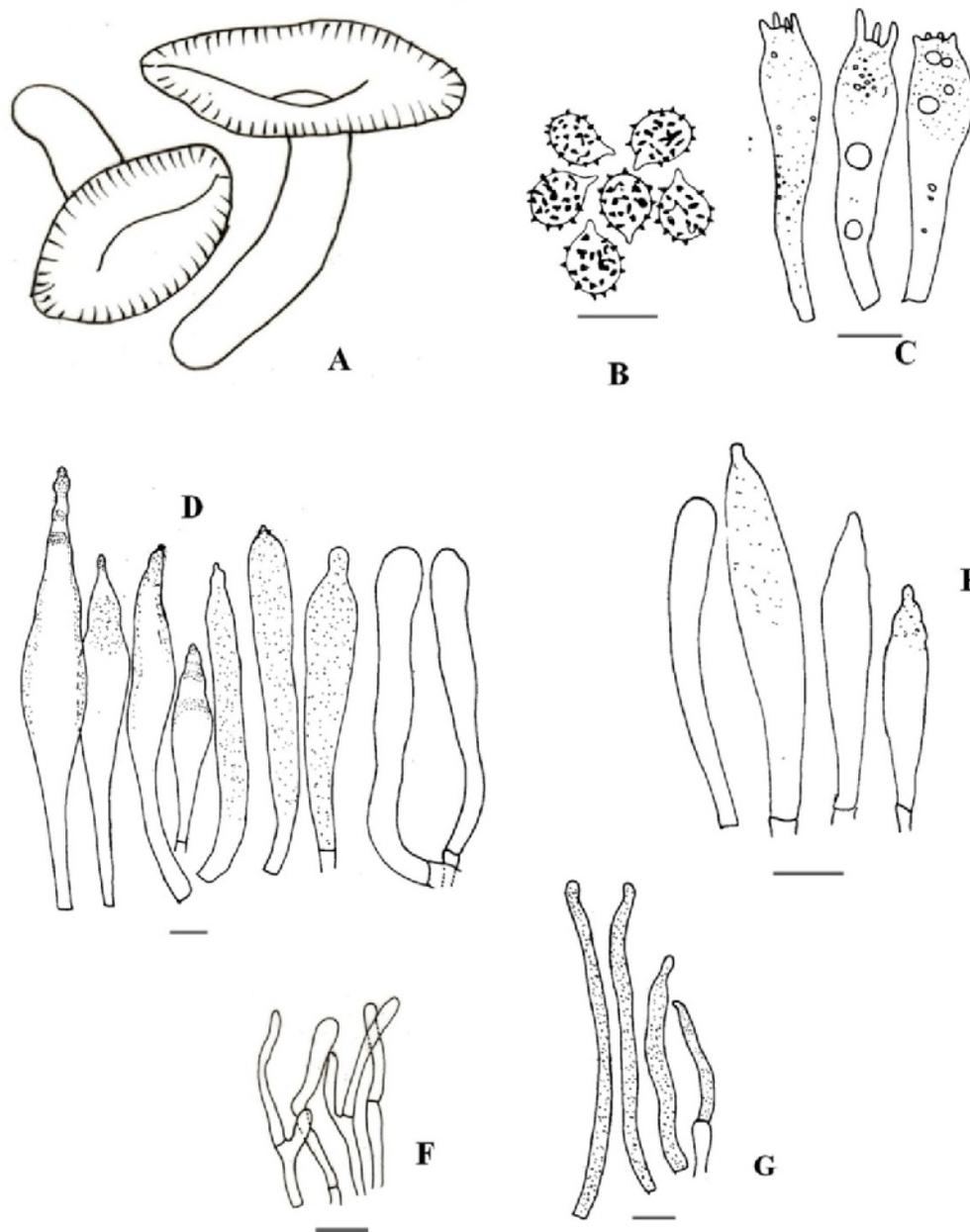
Basidiospores (10.0)10.5–(11.3) × (6.1)6.8–(7.9) μm (Q=1.4–1.6), hyaline, broadly ellipsoidal, verrucose, isolated warts 2–3 connected to form incomplete reticulation, apiculate (1.4–1.8 μm), germ pore absent, oil globule present, cyanophilic and amyloid, spore deposit white. Basidia (29.2)41.1–(51.5) × (6.9)9.4–(13.1) μm (Q=4.3), clavate, 4-spored, sterigmata up to 6.0 × 1.6 μm, thin walled, oil globule present, basal septa without clamps. Pleurocystidia (47.6)65.5–(76.0) × (8.1)9.4–(11.1) μm, cheilocystidia (45.2)51.7–(62.6) × (7.5)7.9–(8.2) μm, oil globule present, clamp connections absent.

Pileipellis (2.2)2.6–(3.0) μm, weak trichoderm, Pileus cystidia (43.5)63.8–(75.1) × (2.8)3.7–(4.7) μm, hyphae irregularly arranged, thin walled. Hymenophoral trama (11.7)17.7–(24.1) × (11.5)13.7–(16.6) μm thick sphaerocysts and connective hyphae. Subhymenium 10–13 μm single cell (5–11 μm). Hymenium 30–35 μm. Stipitopellis (16.8)29.3–(38.7) μm wide.

**Collection examined:** India- Himachal Pradesh- Shimla- Kufri: alt. 2290 m a.s.l.; GPS 31°6'N 77°15'E, mixed forest, Oak community, present among grasses. Shilpa Sood, DMR Acc. No. 35/15, July 27, 2015.



**Figs. 25 (A–G) *Russula subfoetens*:** A) Basidiocarps in natural habitat; B) Gill attachment; C) Pileus surface with striations; D) Pleurocystidia; E) Pileipellis with pileus cystidia; F and G) Basidiospores in SEM. Scale bars: D–E=10 μm; F= 3 μm; G=1 μm.



**Fig. 26 (A–G): *Russula subfoetens*:** A) Basidiocarps; B) Basidiospores; C) Basidia; D) Pleurocystidia; E) Cheilocystidia; F) Pileipellis; G) Pileus cystidia. Scale bars: B–G=10  $\mu$ m.

**Discussion.** This fungus is characterized by its yellowish coloured pileus, yellowish stipe and light-yellow spore deposit. It is usually gregarious in hardwood and mixed forests near *Quercus*. *R. subfoetens* is similar in appearance to *R. foetens*, not clearly distinguished in appearance from *R. foetens*, except that odour is sweeter almond scent, less nauseating. Our specimen shared all the characters of *R. subfoetens* except having larger spore size  $6.8\text{--}9.4 \times 5.6\text{--}7.3 \mu\text{m}$  (Romagnesi, 1985) *R. subfoetens* reported from Uttarakhand by Atri and Saini, (1986) and Saini

and Atri, (1989). In the present study, it is being reported for the first time from of Himachal Pradesh.

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